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STUDY OF CODISPOSED MUNICIPAL AND TREATED/UNTREATED INDUSTRIAL WASTES

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16. ABSTRACT

A study was undertaken to determine the long-term effects of codisposal of industrial waste (IW) and municipal solid waste (MSW) under controlled, simulated landfill conditions. Three IW's (treated or untreated by solidification) were disposed with MSW in nine specially designed test cells at an approximate volume ratio of 1:4. The sealed test cells were leached with distilled water at a rate of 1.27 cm per week. Leachate was collected anaerobically and analyzed for 28 parameters monthly or quarterly over a 4-year period. The three IW's were an electroplating waste (EPW), a chlorine production brine (CPB), and a glass-electronics etching sludge (GES). Two processes were used for solidification of the wastes: Process A added cement plus a patented ingredient to waste, and Process B mixed waste with lime and flyash.

In all cases, the codisposal of treated or untreated IW and MSW had significant effects on the nature of the leachate produced. All IW's increased the pH of the leachates from about 5.3 to 6.3, which alone could affect component solubilities and biological activities of the MSW. The GES inhibited biological activity in the MSW to the greatest extent, and the EPW inhibited it less. The CPB had little or no effect on the MSW biological activity. Both pretreatment systems greatly decreased the apparent effects of IW on the biological activity in the MSW.

Heavy metals in the untreated and treated IW's generally did not appear in the MSW leachates in appreciable amounts. However, heavy metal concentrations were generally increasing in the leachates during the last year of the study.

IW's containing soluble salts (CPB, for example) are not good candidates for disposal with MSW, even after pretreatment. Levels of salts from CPB test cells were high and consistent over the entire study period, even when the CPB was pretreated.

Interaction of leachates with a 31-cm layer of soil at the bottom of the test cells produced only minor modifications in leachate quality. However, interaction of soil and leachate can increase rather than reduce the pollution potential of the leachate.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of solid and hazardous wastes. These materials, if improperly dealt with, can threaten both public health and the environment. Abandoned waste sites and accidental releases of toxic and hazardous substances to the environment also have important environmental and public health implications. The Hazardous Waste Engineering Research Laboratory assists in providing an authoritative and defensible engineering basis for assessing and solving these problems. Its products support the policies, programs and regulations of the Environmental Protection Agency, the permitting and other responsibilities of State and local governments and the needs of both large and small businesses in handling their wastes responsibly and economically.

This report presents results on the long-term effects of co-disposal of industrial wastes (treated by solidification and untreated) and municipal solid waste (MSW) under controlled, simulated landfill conditions. Three industrial wastes were disposed with MSW in nine specially designed test cells. The co-disposed wastes were leached and the resulting leachate collected, analyzed and compared. The results indicate that there are benefits to co-disposing wastes. For further information, please contact the Land Pollution Control Division of the Hazardous Waste Engineering Research Laboratory.

David G. Stephan, Director
Hazardous Waste Engineering Research Laboratory

ABSTRACT

Three industrial wastes (IW), with or without solidification, were codisposed with municipal solid waste (MSW) in nine, large (9.65 cu m total volume), specially designed test cells. MSW and treated or untreated IW were loaded in the test cells in approximately 4:1 ratio by volume. The sealed test cells were leached with distilled water at a rate of 1.27 cm depth/wk. The leachate was collected anaerobically and analyzed for 28 parameters on a monthly or quarterly basis over a 4 year period. The three IWs were an electroplating waste (EPW), a chlorine production brine (CPB), and a glass-electronics etching sludge (GES); the two solidification/stabilization treatment systems added either cement plus a patented ingredient (Process A), or lime and flyash (Process B) to produce solid products.

Four test cells loaded with only MSW were included in the study as controls; of these, 2 were smaller, having half the height and diameter, i.e., 1/8th the volume. Leachates first appeared when the moisture content of the MSW in the large cells was about 0.5 l/kg dry MSW and 0.8 l/kg in the smaller cell. Leachates from these four cells were collected and characterized so that the effects of added IW could be demonstrated. The MSW leachate characteristics were variable, but were typical of those described in other field and laboratory studies. Comparison of leachates from the smaller and larger test cells is discussed.

In all cases the codisposal of either treated or untreated IW with the MSW had significant effects on the character of the leachates produced. Inclusion of any of the untreated IWs increased the pH of the leachates from around 5.3 to around 6.3, which in itself would be expected to affect component solubilities and biological activities. The GES appeared to inhibit the biological activity in the MSW to the greatest extent; the EPW to a lesser extent; while the CPB had little or no effect. Both pretreatment systems greatly decreased the apparent effects of IW on the biological activity in the MSW.

In general, heavy metals in the added, untreated IWs did not find their way into the MSW leachates in appreciable amounts. Neither did test cell containing solidified IW have significantly higher average levels of heavy metals in their leachates. The codisposal of IWs containing high levels of heavy metals with MSW may be an acceptable option for highly alkaline IWs. However, the heavy metal concentrations were generally increasing in the leachates during the last year of this study so that longer-term studies are warranted.

The high level of soluble salt in the CPB was immediately apparent in their leachates. Pretreatment by either process did reduce the initial leachate salt concentrations but the levels of salts from these test cells were high and consistent over the entire study. IWs containing soluble salts are apparently not good candidates for codisposal with MSW even after the pretreatment procedures used here.

Detailed analysis of the behavior of other parameters and the interaction of the leachates with a 0.31 cm soil layer underlying the wastes are discussed.

This report is submitted in fulfillment of IAG-D4-0569 by the U.S. Army, Corps of Engineers, Waterways Experiment Station under sponsorship of the U.S. Environmental Protection Agency. It covers work performed from April 16, 1978, to September, 1983.

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The guidance and support of Mr. Robert E. Landreth and Mr. Norbert B. Schomaker, of the Land Pollution Control Division, Hazardous Waste Engineering Reseaarch Laboratory, U.S. Environmental Protection Agency is gratefully acknowledged.

SECTION 1
INTRODUCTION

Disposal of industrial wastes (IW) has become increasingly expensive and difficult due to heightened public awareness and regulatory restrictions. In past practices, almost all types of waste including most solid, liquid or sludge IWs were indiscriminantly disposed at local dump sites. Increasing interest and progress in landfilling technology quickly followed the banning of burning at dumpsites by the Environmental Protection Agency. Landfilling is now the recommended, and nearly universal, method of disposal of municipal solid wastes (MSW) while IWs, especially those containing liquids or hazardous materials, have been relegated to special "secure," hazardous waste landfills or other disposal technologies such as incineration.

MSW-IW CODISPOSAL

Currently, little information is available in the U.S. concerning the effects of the codisposal of IW and MSW even though this historically has been the most common disposal alternative (1, 2, 3). Houle et al (4) estimated the effects of landfill leachates on metal losses from several IWs using short-term (24 and 72 hr) serial, batch extractions of the IWs with distilled water and landfill leachates. The concentrations of cadmium, copper and nickel were found to be much higher (100 to 3000 times) in the landfill leachate extracts than in the distilled water extracts. The authors stated that their result dramatically demonstrated the potential hazard that may result from disposing of certain industrial wastes with MSW and that their study raised serious question on the advisability of codisposal in general. These results and others (5, 6, 7) form a part of the basis of using acetic acid at pH 4.5 in the EPA Extractant Procedure.

On the other hand, codisposal with MSW is the recommended practice for many hazardous wastes in England (8, 9). Researchers there claim that the scientifically determined disposal of hazardous wastes with municipal refuse can be an acceptable, and even the preferred management alternative for many toxic substances such as dilute wastes (liquids and pesticides) and for more concentrated materials such as asbestos, refractory metal slags and metal-hydroxide sludges, and all biodegradable wastes (9, 10).

A long-term study of codisposal of several IWs with MSW under different leaching regimes, including gas collection and active leachate collection and analysis was begun in the mid 70s by the U.S. EPA (5, 11). Interim reports have concluded that after about 2 years of leaching the added IWs had no effect upon organic, nutrient or oxygen demand leachate parameters, but may have had an effect upon metalic ion concentrations and gas production rates depending upon the composition of the specific IW. After about 7 years of continuous leaching in the same cells (11), it was concluded that MSW test cells with IW produced leachates sooner and retained less moisture (i.e., had lower "field capacity") than test cells containing MSW-only. Also confirming the preliminary results after the full 7 years, higher rates of metal losses were seen (iron, cadmium and nickel), but no effect was apparent on MSW decomposition rates or organic or nutrient loss parameters.

McCabe (12) proposed to codispose two individual sludges (settling lagoon residuals) with MSW in a sanitary landfill. Both IWs were high in organics and had appreciable levels (0.1 to 5%) of several heavy metals (chromium, copper, lead and zinc). Short-term leaching experiments with acid rain water (pH 4.5) or acetic/butyric acid ("2:1 ratio diluted to pH 4.0 with distilled water") resulted in relatively low losses of heavy metals from the very alkaline sludges. With these data in hand, McCabe concluded that the environmental impact of the leachates was negligible. Attenuation by underlying soil of such pollutants which would escape in leachates was claimed to insure no environmental damage.

THE LANDFILL ENVIRONMENT

The sanitary landfill method of solid waste disposal depends largely upon anaerobic biological activity to stabilize the decomposable fractions of the MSW. The anaerobic process is considered to proceed through two identifiable phases (13, 14, 15) with conversion of the larger organic molecules into intermediate size molecules including mainly the volatile short-chained organic acids (acid fermentation). Subsequent conversion of the short-chained acids produces carbon dioxide and methane (methane fermentation). The second phase of methane formation is considered to be the rate controlling step in the anaerobic process. This phase proceeds at a much slower rate and is more sensitive to environmental stresses than acid fermentation. Methane forming organisms generally require strict anaerobic conditions, a near neutral pH, and an absence of inhibitory substances. If acid production exceeds the rate of methane formation to an extent greater than the capacity of the system to buffer the acids produced, the pH will fall below the level at which the methane producing organisms can survive and the methane producing bacteria will cease to function efficiently. In a typical anaerobic digestor, the volatile acids concentration will initially rise to a peak value and then decrease with concurrent changes in the concentration of the individual volatile acids. The pH of the system may decrease during the increase in volatile acids and will then rise steadily while the volatile acids diminish as a consequence of methane and carbon dioxide production during the second, methanogenesis phase.

OBJECTIVES OF THIS STUDY

This study addresses the effects of IW/MSW codisposal in a simulated MSW landfill environment. Eleven large (181 cm dia) test cells were filled with only MSW, or with MSW and one of three IW wastes used in the study. The wastes were an electroplating waste (EPW), a chlorine production brine (CPB) and a glass-electronics etching sludge (GES). All wastes were collected from actual industrial waste streams.

A second aspect of this study is directed toward the possible use of chemical solidification/stabilization of the IW to lessen the contaminate loss in the codisposed IW and MSW (16). Two commercially available methods are included--a cement-based, proprietary process (A) and a lime-flyash, pozzolanic process (B). Separate steel test cells were set up including MSW-only, MSW with untreated IWs, and MSW with IWs treated by the two selected processes. Continuous leaching of the test cells was continued for over 4 years (1510 days). All leachates were analyzed for 28 parameters at monthly or quarterly intervals. Leachate samples were collected from above and below a 30 cm soil layer at the bottom of each test cell.

This report describes the overall results of the leaching data from all three IW wastes, treated and untreated, for leachate samples collected above and below the soil layer over the complete 1510-day study period. A preliminary report of this data, restricted to 10 parameters in the below-soil leachate samples from the electroplating waste (EPW) test cells over the first 1000 days of leaching, has been published (17). This report concluded that the codisposal of untreated electroplating waste with MSW did not significantly alter the quality of the emerging leachates over the first 1000 days of leaching. Seven of the 9 heavy metals reported were actually produced at lower levels from the MSW test cells containing untreated EPW than from the identical test cell containing only MSW or solidified EPW with MSW. These lower metal productions were attributed primarily to the more alkaline pH of the leachates from the test cells with untreated EPW (0.5 units more alkaline).

Also, four test cells containing only MSW were hermetically sealed and outfitted with gas collection and monitoring instruments so that gas volumes and composition could be monitored. Results of these studies, which are not included in this report, have appeared elsewhere (18, 19, 20) and a final report is now in press.

SECTION 2
CONCLUSIONS AND RECOMMENDATIONS

Leachates from the test cells containing only MSW were typical of those reported in the literature. Initial leachates had very high organic loadings (chemical oxygen demands of up to 45,000 mg/l and biochemical oxygen demands of up to 35,000 mg/l), consistent slightly acidic pHs of around 5.3, and significant ionic loadings (conductivities of over 10,000 μmho/cm). Early samples of leachates exceeded drinking water standards (DWS) for all constituents for which standards have been established except copper. Most serious metal loadings were iron and manganese which had average concentrations throughout the study period of over 1000 and 100 times the DWS, respectively, perhaps due to their biological reduction to more soluble forms in the anaerobic leachates. Arsenic, chromium, selenium, zinc and chloride also exceeded drinking water standards in their average concentrations in the leachates.

A considerable amount of variability was seen between constituent levels in leachates from the 4 different test cells which contained only MSW as well as between subsequent leachates samples from the same test cell. This variability in the MSW-only leachates sets the lower limit for detecting the effects of addition of IWs to the MSW. The large size of the test cells, and the mixing of the MSW before loading, held this variability to a minimum.

Of the 4 control test cells which contained only MSW, two were the same size as those containing MSW+IW (3.66 m depth by 1.83 m dia.). The other two cells were smaller having half the MSW depth and half the diameter, so that they contained about one eighth the MSW volume; but they received twice the leachate volume per kg dry MSW. Comparison of the results of the 2 test cell sizes indicated that the leachate concentrations of many metals and the oxygen demand parameters appeared to be solubility limited. This meant that their rate of loss from the MSW was proportional to the amount of leachate produced and largely independent of the amount of waste or its configuration. However, losses of the highly soluble constituents, such as sodium and chloride, were more nearly proportional to the amount of MSW loaded into the test cell rather than to the volume of the leachate produced.

In all cases, the codisposal of either treated or untreated IW with the MSW in the test cells had significant effects on the levels of the complex of constituents for which analyses were made. Inclusion of any of the three untreated IWs with the MSW increased the pH of the leachates from around 5.3 to around 6.3. This change in pH itself would be expected to affect the rates of biological activity and the solubilities of some of the constituents in the leachates.

Of the three IWs, the untreated GES appeared to have the greatest inhibitory effect on the microbial activity in the MSW; test cells holding untreated GES had leachates with lower chemical and biochemical oxygen demands (both 28% of the MSW-only leachates on an average), total organic carbon (29%), and total volatile acids (34%). The untreated EPW had a smaller inhibitory effect, these parameters averaging from 50 to 75% of their values in the MSW-only control leachates. The untreated CPB had little or no effect on the levels of these parameters even though it did cause a similar pH change. The inhibition appears to be due to minor components such as toxic metals rather than either high soluble salt levels or high pH. Leachates from the test cells containing any of the IWs which had been solidified produced leachates with pH values and organic parameters similar to the MSW-only leachates; i.e., both treatment processes appeared to overcome the inhibitory effects of the IWs on the microbiological processes occurring in the MSW cells.

In general, heavy metals in the added IWs were not readily leached out of the test cells. The EPW, for example, which contained the highest levels of the heavy metals--6% chromium, 10% copper and 0.3% nickel--did produce significantly increased levels of these three metal ions in the leachates from the test cell containing the untreated EPW. However, increases in the total amount of these metals leached from these test cells are very small when compared with the total amount of the metals added to the test cells. Specifically, of the 45 kg of chromium and 70 kg of copper which were added to the MSW with the untreated EPW a total of only 72 mg of chromium and 785 mg of copper were leached over the entire 4 year leaching period--a loss of only about twice the total amount lost from the test cells containing only MSW. Evidently the loss of the heavy metals is limited to a large extent by the solubility of the metals in the leachates and so is proportional to the amount of leachate produced and not to the amount of the metals contained in the MSW-IW mass. Test cells containing MSW and treated EPW did not have significantly higher levels of chromium or copper in their leachates, but did of nickel. Leachates from test cells containing MSW plus treated or untreated CPB or GES did not show significantly higher (or lower) levels of metals as might be expected since neither waste contained appreciable heavy metal levels.

The codisposal of IWs containing high levels of heavy metals in hydroxide sludges may be an environmentally acceptable option since the added metals were not found in large quantities in the MSW-IW leachates. Indeed, one would have had difficulty telling which test cell contained the untreated EPW in this study simply from the leachate composition. However, two cautionary notes: First, while this experiment extended over 4 years of leaching, the metal levels in the leachates were slowly increasing in the last year of the study; their levels could increase appreciably over the next few years (or much later for that matter) since they will perpetually remain in the landfill until leached out. And second, the added IW appears to inhibit and/or modify the microbial activity in the MSW mass so that again, long-term results cannot be safely predicted from the currently available data. Knowledge of the effects of specific metal ions on MSW microbial stabilization is necessary before the effects of codisposal of individual wastes with MSW can be assessed with any certainty.

Soluble salts in the IWs were quite apparent in the leachates from those test cells. The test cell containing MSW plus the untreated CPB produced leachates with extremely high sodium and chloride concentrations. Values up to 20% sodium chloride by weight were found in initial leachate samples. Even after 4 years of leaching the levels were still above 1000 mg/l even though most of the sodium and chloride added in the original CPB had been leached from the test cell by this time. Pretreatment of the CPB by either solidification process did reduce the initial very high concentrations of the soluble, monovalent ions in the leachates, but their losses were still high and consistent (at about 10,000 mg/l of sodium chloride) for the length of the study. Sodium and chloride were also found at consistently higher levels (400 to

600 mg/l) in leachates from test cells containing both treated and untreated EPW and GES, but this is only 2 to 3 times their average concentration in the MSW-only leachates. The treated EPW and GES test cells show lower but still slightly elevated levels of soluble salts. Although the soluble salts in the CPB were lost in very high concentrations, their presence did not seem to be as inhibitory to the MSW microbial action as the very low levels of the toxic elements from the other IWs. The codisposal of IWs containing high levels of soluble salts in MSW landfills does not seem to be an environmentally safe procedure due to the rapid and large losses of the salts to leaching waters even after solidification pretreatment.

The divalent cations, calcium and magnesium, were prevalent in all leachates averaging around 500 and 90 mg/l respectively in the MSW-only leachates. The presence of either treated or untreated IW increased their concentration by 100 to 200%. Calcium was a major component in the IWs and the treatment reagents, and was found near its solubility limit in all IW leachates (600 to 800 mg/l). Iron, a good indicator of landfill leachate, was found at constant or increasing concentrations (300 to 500 mg/l) in all leachates from test cells containing MSW-only or MSW plus treated IW. Iron concentrations in the leachates are probably an indicator of the overall microbial activity (at least of the iron reducing bacteria) in the waste mass. Addition of any of the untreated IWs, which themselves average around 1% iron, to MSW consistently lowered the concentration of iron in the leachates produced, most likely due to the inhibition of the microbial activity in the test cells.

The interaction of the leachates from the test cells with 0.31 m layer of a clayey-sand soil produced only minor modifications in leachate quality. The majority of constituents were not affected by, or increased in concentration after, passage through the soil layer. Only arsenic and total phosphate were significantly removed from the leachates by the soil layer over the length of the study. Aluminum, cadmium and mercury were added to the leachates from the soil in significant amounts. The interaction of MSW leachates with underlying soils requires more study. It appears that the soil cannot be considered simply as an absorber of materials from the passing leachates. The anaerobic, slightly acidic leachates can interact with the soil and remove significant amounts of selected constituents from the soil, which may increase the overall pollution potential of the leachate rather than reducing it.

SECTION 3
MATERIALS AND METHODS

INDUSTRIAL SLUDGE SELECTION AND CHARACTERIZATION

The three industrial wastes (IW) included in this study are an electroplating waste (EPW), a chlorine production brine (CPB), and a glass etching-electronics sludge (GES). They are representative of the IW sludges used in several other EPA studies in which their physical and engineering properties, and leaching characteristics in small-scale, long-term column leaching experiments were determined (21, 22, 23). All three IW sludges are largely inorganic in composition, have high levels of toxic heavy metals and/or soluble inorganic salts, and are produced in large quantities in the U.S. These wastes are considered to be some of the most difficult to contain and are the basis of many environmental problems (24).

Selected characteristics of the three IW sludges and their identification numbers are displayed in Table 1. All three wastes contain 30 to 60% solids, have high specific gravities and are slightly to moderately alkaline as is typical of lime-based sludges. The small median grain size and large percentage of solids passing a 200-mesh screen are typical of sludges which are difficult to dewater. The sludges remain thixotrophic when wet and have relatively low permeabilities, especially after settling for extended periods of time.

The actual IW samples used were collected directly from industrial waste streams or disposal sites in the northeastern U.S. At the time of collection all the IWs were being dewatered by ponding and disposed without further treatment. None were being recycled or reclaimed. Large samples of the wastes

TABLE 1. SELECTED CHARACTERISTICS OF WASTES USED IN THIS STUDY

Parameter	Electroplating Waste	Chlorine Prod. Brine	Glass Etching Sludge
ID Number	200	800	900
% Solids	32	59	47
Specific Gravity	2.70	2.82	2.76
Slurry pH	7.6	9.5	8.3
Median Grain Size (mm)	0.013	0.024	0.019
% Passing #200 Sieve	97	96	89

(Continued)

NOTE: Physical properties taken from Bartos and Palermo (22).

TABLE 1. (Concluded)

Parameter	Electroplating Waste	Chlorine Prod. Brine	Glass Etching Sludge
Permeability (cm/sec) (Falling Head)	3.1×10^{-6}	8.1×10^{-6}	3.5×10^{-5}

(several cubic yards) were collected and transported to The Waterways Experiment Station where they were temporarily stored in weather-tight, covered bins. Before any subsamples were removed, the sludges were well mixed to reconstitute the waste to original condition.

The electroplating waste (#200) is composed of a combination of wastes from phosphatizing and metal cleaning operations with waste solids produced from the treatment of spent plating liquors. The spent plating solutions containing chromates are acidified, treated to reduce the hexavalent chromates to the less toxic trivalent form with sulfur dioxide or sodium metasulfite, and then raised to pH 8.0 with sodium or calcium hydroxide to precipitate the trivalent chromium as $Cr(OH)_3$. The cyanide containing liquors are treated with sodium hydroxide and chlorine gas or sodium hypochlorite to oxidize the cyanide. The metals present, such as chromium, copper and zinc are then precipitated as hydroxides. The sludge remains at approximately pH 8.0 due to the addition of lime or caustic. The EPW sludge was collected from an open lagoon which allowed to evaporate during summer so that the remaining dryer waste be removed and transported to a permanent disposal area in the fall. The waste is a bright green, clay-like material. Bulk analyses (see Table 2 and Appendix A) indicate that this waste is over 1% in calcium, chromium, copper, iron, sodium, chloride, sulfate and silicate. Other metals present in appreciable amounts are aluminum, boron, cadmium, manganese, nickel, lead and zinc.

The chlorine production brine waste (#800) is made up primarily of materials present as impurities in rock salt as it is dissolved to form brine for electrolytic production of chlorine and caustic soda. Impurities such as calcium sulfate, calcium carbonate and other slightly soluble materials are left as a sludge in the brine saturator. About 20% of the final sludge is produced in treating the spent liquor from the mercury electrolysis cell before recycling. The blended sludge contains calcium sulfate and carbonate along with other metal carbonates and some sodium hydroxide which produces an alkaline product. Primary contaminants in this tan, granular material are mercury and various alkali salts.

The glass etching electronics sludge (#900) is made up of settled solids from a neutralization and treatment plant after calcium hydroxide is added to the wastewater. The sludge which forms typically consists of about 20% calcium hydroxide, 8% calcium fluoride, 8% calcium silicates and silica, 3% calcium sulfate, and 2% aluminum oxide and hydroxide. About 3% organic matter from domestic sewage which has received primary biological treatment has also been added to the final waste product in the CES used in this study. The primary constituents of this light brown sludge are calcium fluoride and alkali salts. Low levels of several heavy metals are also present in the sludge.

TABLE 2. BULK ANALYSES OF THE INDUSTRIAL WASTES USED IN THIS STUDY

Constituent	Electroplating Sludge (200)	Chlorine Prod. Brine (800)	Glass Etching Waste (900)
Aluminum	4700	<1200	16,000
Arsenic	41	15	45
Barium	600	500	790
Boron	<1000	<500	<1000
Beryllium	430	0.08	0.37
Calcium	86,000	275,000	280,000
Cadmium	580	0.86	4.3
Chromium	65,000	1500	350
Copper	100,000	300	440
Iron	10,000	2400	6800
Lead	600	26	200
Magnesium	5400	2900	10,000
Manganese	290	160	280
Mercury	BDL	120	6.2
Nickel	2700	60	420
Potassium	660	120	2100
Selenium	19	13	16
Silicon	35,000	15,000	26,000
Silver	6.4	0.05	1.3
Sodium	16,000	71,000	1700
Zinc	7900	170	360
Chloride	220,000.	160,000.	160,000.
Sulfate	270,000.	53,500.	37,500.
% Recovery	80.7%	57.5%	53.6%

NOTE: All values in mg/kg dry sludge solids except % recovery.

Bulk chemical analysis of the sludges was made using eleven different digestion-analytical method combinations. Results of these analyses are summarized in Appendix A. The data presented in Table 2 represents best approximation of actual constituent levels present in the sludges as determined in The WES analytical laboratory. A detailed presentation of the physical and engineering properties of these sludges is given in a report by Bartos and Palermo (22).

IW STABILIZATION/SOLIDIFICATION PROCESSES

Two processors of IW who had participated in earlier WES solidified waste leaching studies (22, 23) agreed to treat samples to be used in this study. Preliminary evaluation of their process solidification effectiveness upon the selected IW sludges had already been accomplished so that the solidification treatments could be undertaken at Waterways Experiment Station.

Process A

This process uses two additives (Portland cement and a proprietary additive) which are mixed with the waste in a patented process which binds the wastes into the chemical lattice of the solid product. The relative proportions of reagents in the final mix determines the physical properties of the treated product. The physical properties of the final product may be designed either to reflect pollutant immobilization, or to be of a consistency best for a specific, ultimate use of the fixed waste.

For this process, the sludges were slurried with a small amount of added water (see Table 3) in a rotary-pan, turbine mixer which held 0.38 m^3 batches (see Fig. 1). After the suspension was well blended and homogeneous the first additive was introduced to the running mixer one scoop (1 liter) at a time. The second reagent was added in 40 kg bag increments and the mixture blended for 3 to 8 minutes. The treated waste mixture was cast into 12 identical 0.61 m diameter parafin impregnated cardboard molds which were 0.61 m in height (Fig. 2). The molds with carts were labeled and covered with plastic before curing for 28 days. The cured casts in their molds are shown in Figure 3. Table 3 lists the formulations of these products.

Process B

Process B uses flyash and lime to produce a solid pozzolan product. The amount of bituminous flyash added is related to the total dry solids in the waste being treated. A final product with a high solids content (around 80%) is considered optimum and dewatering the sludge often is done to reduce the amount of flyash required.

A predetermined weight of waste was blended in the rotary-pan mixer and water was added until the mass slurried. Additional water was added as needed to maintain the slurry. Lime was then added and the mass blended for approximately 5 minutes. Treated sludge was placed into 12, 0.61 m diameter by 0.61 m high molds and compacted in four layers using hand tamps as seen in Figure 4. The surface of each layer was scarified before additional layers were added. The top layer was molded to produce a domal shape so that leachate would not collect on the top. The molds were covered with plastic and cured

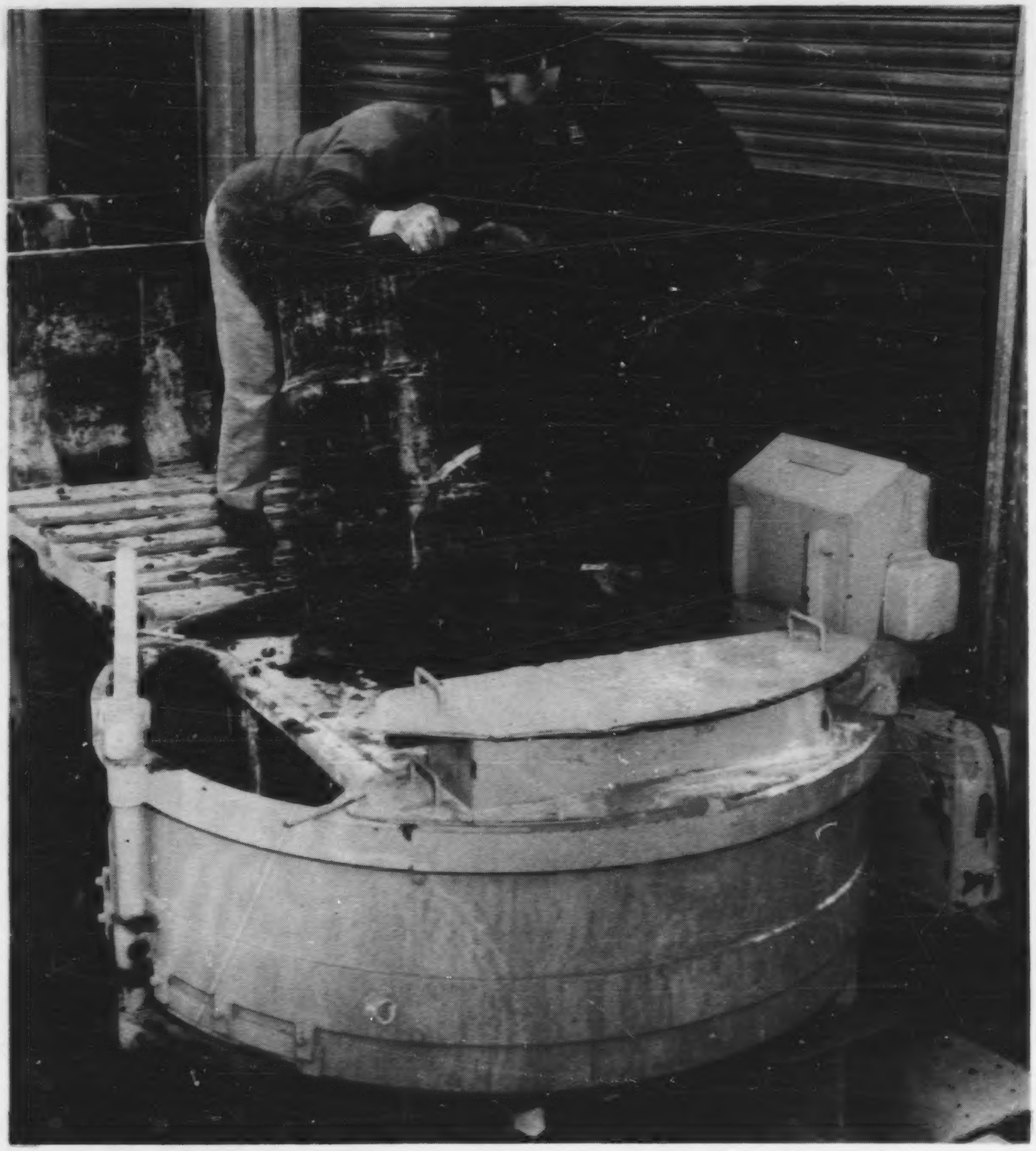

Figure 1. Rotary-pan, turbine mixer.

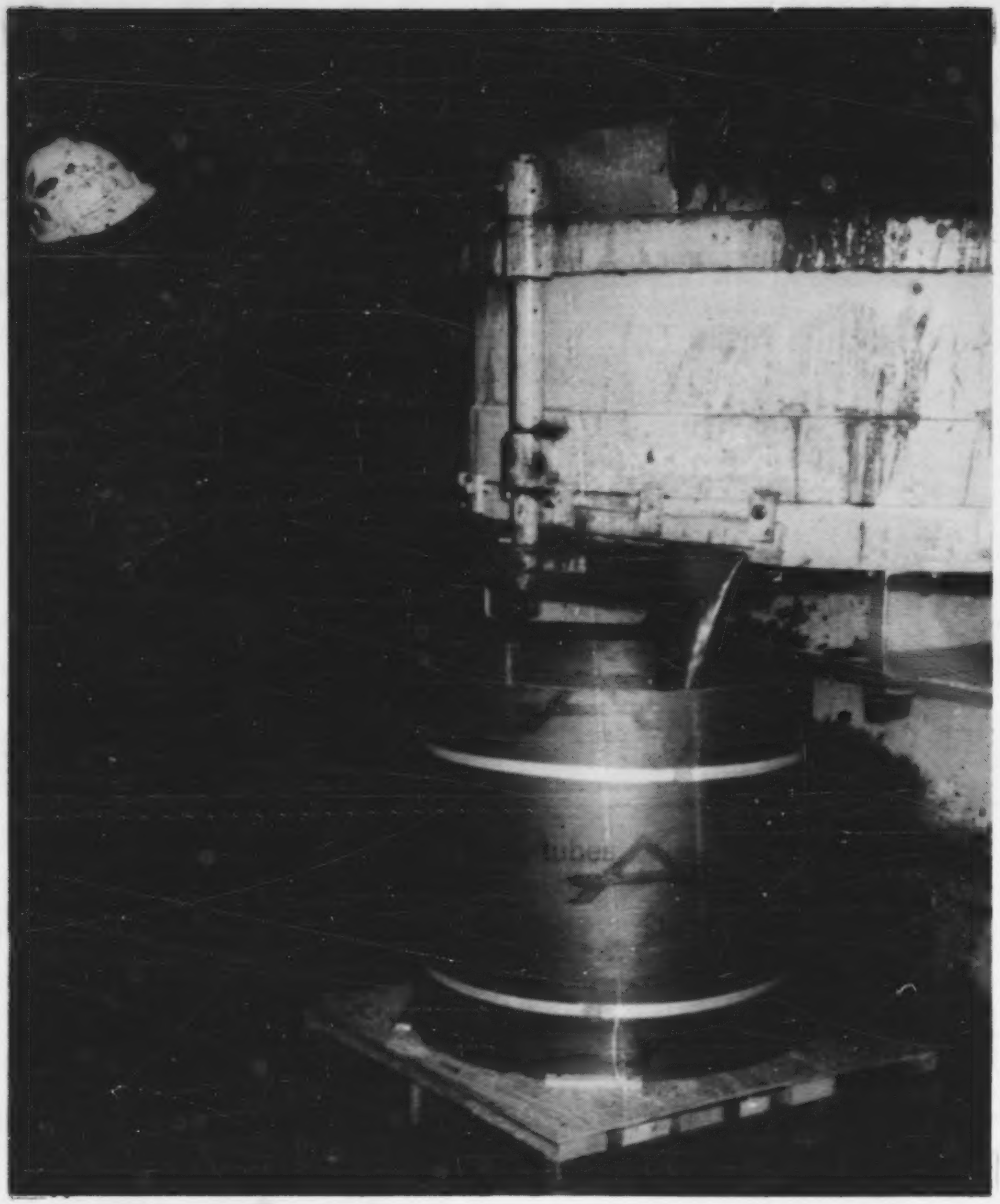

Figure 2. Filling the molds with treated industrial waste.

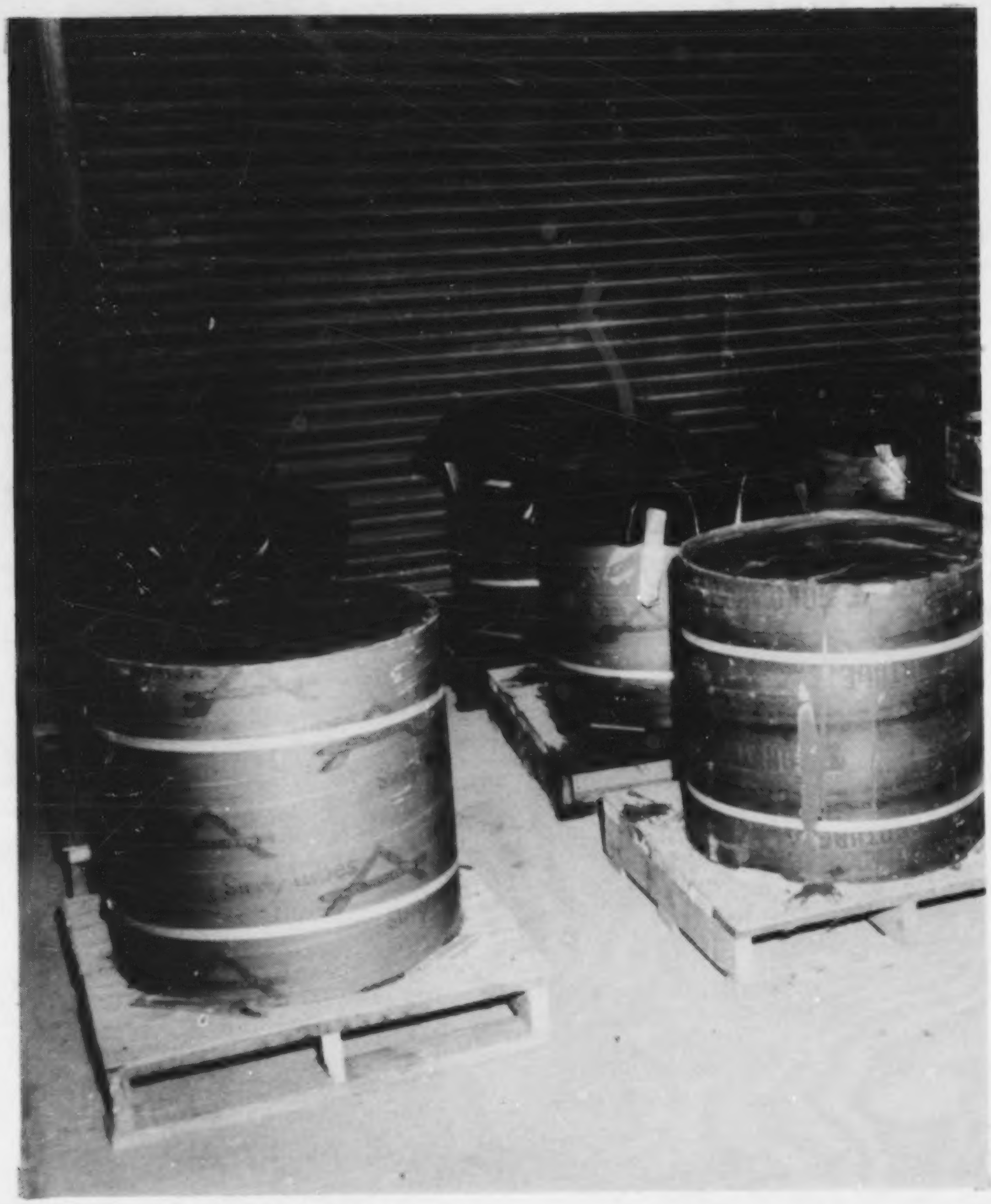

Figure 3. Curing treated industrial wastes in molds.

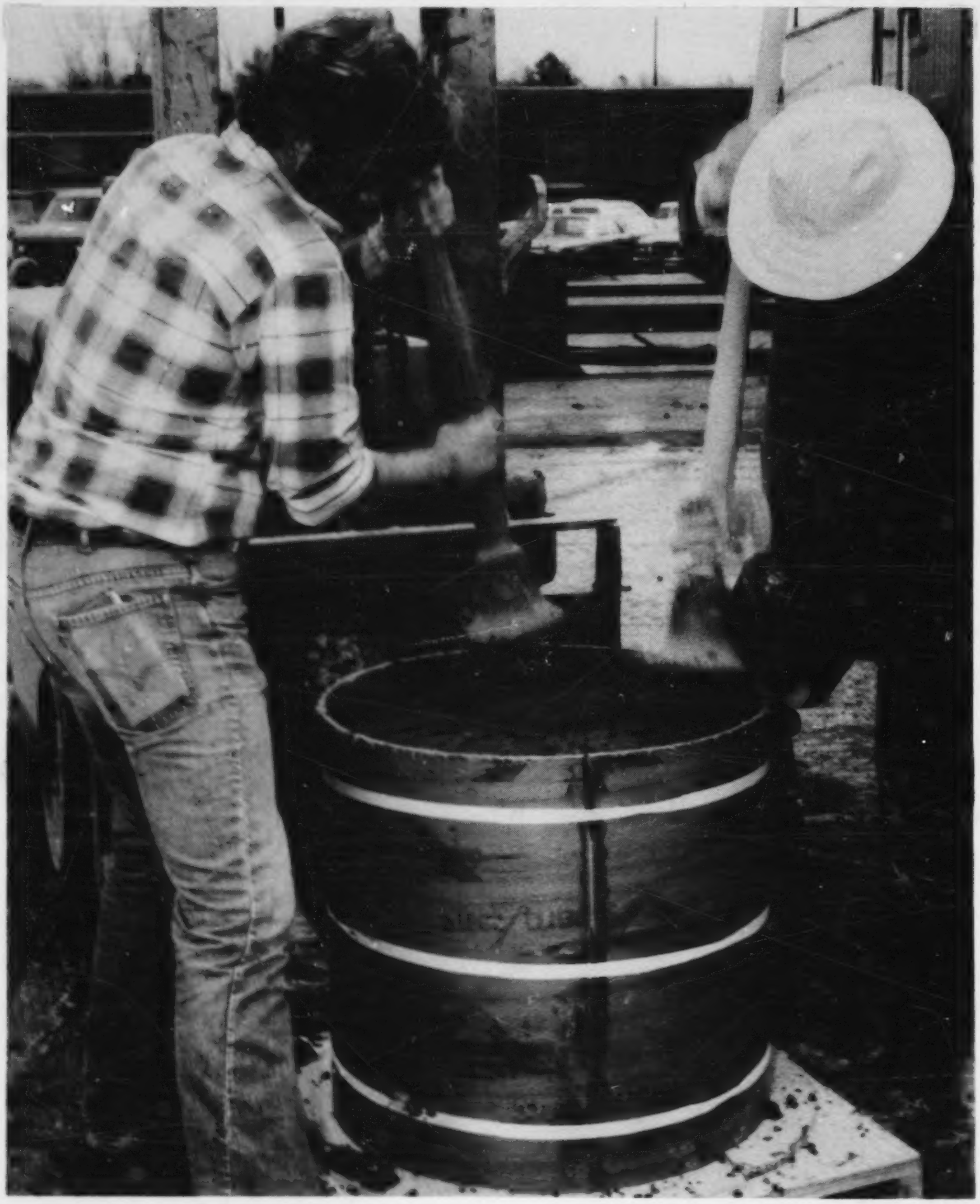

Figure 4. Hand tamping treated industrial waste.

for 28 days. Details of the contents of the process B treated sludges are given in Table 3.

TABLE 3. FORMULATIONS OF THE TREATED WASTE PRODUCTS

IW	Process	Additive(s) (Dry)	Added Water	Dry Sludge Solids	Water in Sludge	Total Water
200	A	26.5	22.5	16	35	57.5
800	A	25	9	39	27	36
900	A	27	9	30	34	43
200	B	51	0.5	15.5	33	33.5
800	B	53	5	25	17	22
900	B	62	14	11.5	12.5	26.5

NOTE: All values expressed as percent weight of the final fixed product.

After the 28 day curing period, all of the treated waste cores (casts) were removed from their molds and moved to a staging area to await test cell loading. Eight of the 12 available cores for each treated waste were selected by the vendors after inspection for damage, soft areas, scars or fissures; no defects were found on any of the cores. The cores were weighed and loaded into the test cells.

The two treatment processes differ markedly in the amount of additive and dry sludge solids in the finished products. Process A used less than half of the weight of additive in its procedure than process B. Process A added between 0.64 and 1.6 times as much additive as dry sludge solids while process B used from 2.1 to 5.4 times as much additive. The difference was also evident in the proportion of dry sludge solids in the final product--between 18 and 41% for process A and 12 to 25% for process B. On the average, nearly twice as much process B product would have to be disposed, as opposed to process A product, to get rid of the same net amount of dry sludge solids.

Source and Composition of Municipal Solid Waste (MSW)

The MSW used in this study was provided by the Sanitation Department of the City of Vicksburg, MS, and by two private haulers operating in Warren County, MS. Residential collection routes were selected for MSW to exclude any commercial, industrial, or hospital wastes. All 15 deliveries, containing 31,662 kg total weight of MSW, were made during mid-week of April 10, 1978. The deliveries were combined into three batches according to the day of delivery. Each batch was placed in a large vault and was "walked down" and mixed with a Caterpillar (D-4), crawler bulldozer to rupture plastic bags and crush cans and bottles. The MSW was further mixed with a front-end loader which was also used to carry the crushed and mixed waste to the scales and test cells. Each batch was sampled for compositional analysis (>200 kg). Each batch was distributed appropriately between the large (eleven) and small (two) test cells.

The subsamples used to determine the MSW composition were weighed and sorted into 10 categories as shown in Table 4 and dried in an adiabatic room at 71 C for 72 hours. The composition of the MSW used in this study was consistent in composition with that determined by Jackson and Streng (24), Chian et al. (25), and Eifert and Swartzbaugh (26). However, the MSW in this study had slightly higher plastic, rubber and leather content, higher fines, and lower food and garden waste (see Myers, (27) for comparison).

TEST CELL DESIGN AND CONSTRUCTION

The test cells were designed to simulate a 1.83 m diameter core through a typical landfill in which IW and MSW might be co-disposed. The test cells were designed so that leaching water (deionized) of known composition and pH could be added in premeasured amounts through the top of the otherwise sealed cells and the resultant leachates could be sampled both above and below the 0.31 m soil liner. The test cells were free-standing and housed in a large-scale facility which was temperature controlled to 25±3 degrees C year around.

The test cells were rolled steel (6.35 mm thick) cylinders as shown in cross-section in Figure 5 and external view in Figure 6. All interior surfaces were coated with an acid and base resistant coal-tar epoxy material to protect the walls from corrosion or leaching by the contained wastes or leaching fluid. Eleven of the test cells were large cells, 1.83 m internal diameter by 3.66 m in height, and two were smaller units, 0.91 m inside diameter by 1.93 m in height. The smaller cells were filled with MSW only and used for evaluating the effects of test cell size on leachate quality. The smaller test cells type had been used in earlier studies (28, 29). All test cells contained polyethylene beads (340 kg, 6.25 mm dia.) in the leachate storage space in the bottom. the non-reactive beads provided soil layer support and pore space storage for leachate.

Each test cell contained a 31 cm layer of selected soil (1440 kg/large test cell) beneath the waste and was fitted so that leachate samples could be taken from below and above the soil layer (see below). The soil selected, which is described in more detail in Appendix B, was in the McLaurin soil series found in Forrest County, Mississippi. This series is a member of several soil associations throughout the southeastern coastal plain. The red-colored soil contained 16% clay (<5 microns), 4% silt (5 to 50 microns) and 80% sand (>50 microns) and had a Unified Soil classification of "Clayey sand" (SC-SM). The soil had high permeability (1.18 x 10^{-3} cm/sec at wet (7% moisture) density of 1766 kg/m^3 at 0.14 kg/m^3 confining pressure) and moderate cation exchange capacity (7.4 meq/100 g). It consisted largely of quartz with small amounts of potassium feldspars and clays. The clays were mainly kaolinite with no hydrated halloysite or smectite.

TABLE 4. COMPOSITION OF MSW

Category	Batch #1	Batch #2	Batch #3	Average
Paper	49.7	48.5	37.7	45.3
Metals	11.1	8.2	10.4	9.9
Plastics, Rubber and Leather	9.8	9.3	8.0	9.0
Glass	6.0	4.9	9.9	6.9
Textiles	2.5	1.9	3.9	2.8
Disposable Diapers	2.6	1.3	2.8	2.2
Food Waste	1.0	1.9	0.82	1.2
Wood	0.68	0.76	0.22	0.55
Garden Waste	0.25	0.62	0.64	0.50
Fines: Rock, Dirt, Ash (<2.54 cm)	16.4	22.7	25.6	21.6
Total Sample (dry weight kg.)	178	180	214	191
Percent Moisture (% of total wt.)	21.1	9.5	13.4	14.7

NOTE: All values in % dry MSW solids.

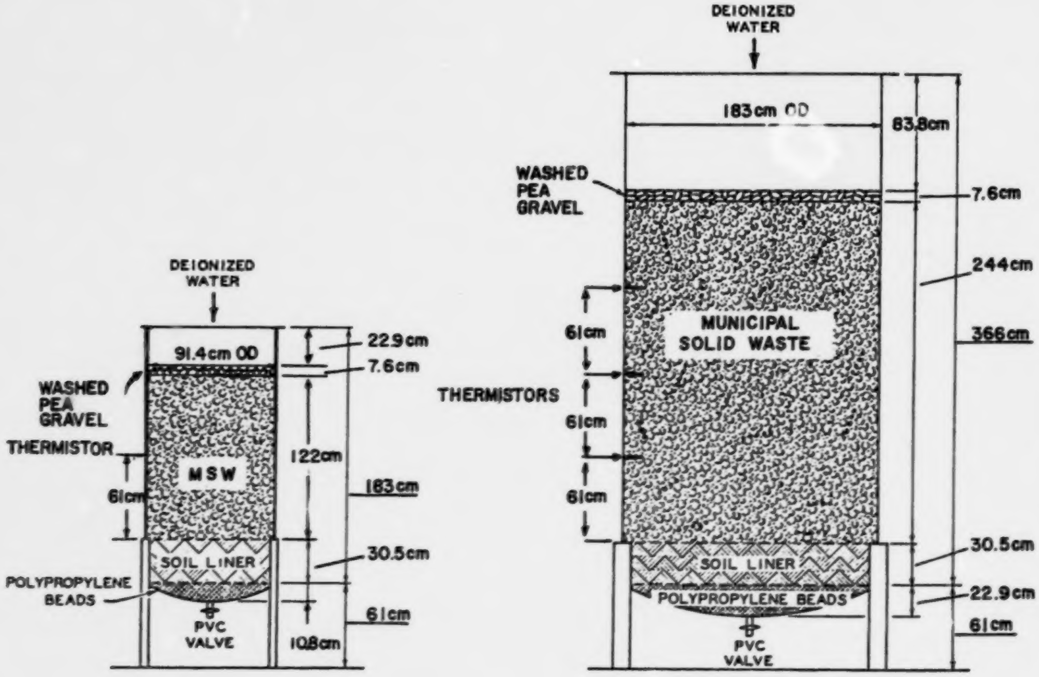
DEIONIZED WATER
91.4cm OD
22.9cm
7.6cm
WASHED PEA GRAVEL
THERMISTOR
61cm
MSW
122cm
183cm
30.5cm
SOIL LINER
POLYPROPYLENE BEADS
PVC VALVE
61cm
10.8cm
DEIONIZED WATER
183cm OD
83.8cm
WASHED PEA GRAVEL
7.6cm
244cm
61cm
MUNICIPAL SOLID WASTE
366cm
THERMISTORS
61cm
61cm
30.5cm
SOIL LINER
POLYPROPYLENE BEADS
22.9cm
61cm
PVC VALVE

Figure 5. Cross-section of large and small test cells containing only MSW.

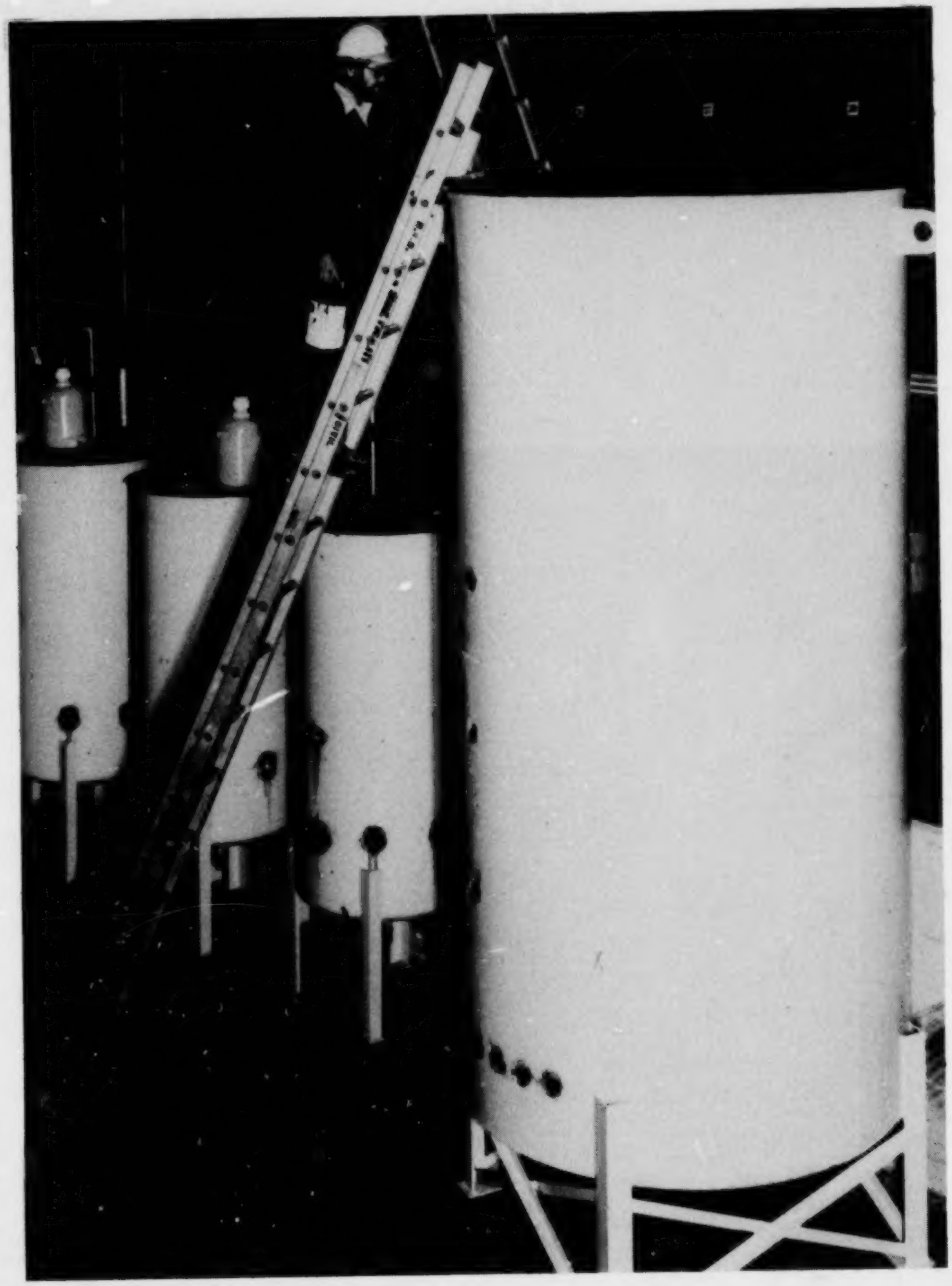

Figure 6. Small and large test cells.

TEST CELL INSTRUMENTATION AND LEACHATE SAMPLING PORTS

Accumulated leachate was collected from below the soil layer (below-soil samples) by draining the test cells through a stainless steel valve fitted to the center of the concave (upward) test cell bottom. Each test cell was also fitted with a 1.27 cm ID glass stand pipe which was connected to the leachate collection tap at the bottom of the test cell via polypropylene tubing. As leachate was generated by percolation of water through the test cell profile, the level of leachate produced was monitored through the level in the standpipe. Leachate was not allowed to back up to cause saturation conditions, in the MSW.

Prior to test cell loading seven ports were drilled through the steel walls of the large test cells, and were positioned equidistant around the cell circumference at the level of the soil-MSW interface. Three other ports were spaced at 61 cm intervals vertically above the soil-MSW interface. To insure a water and air tight seal at each instrumentation port, a 1.9 cm polyvinyl chloride (PVC) female adaptor was epoxied into the port hole. The epoxy (Furan Plastics, 126 Epibond and 9812 Hardener) was of a type specially formulated to bond PVC to steel. A removable, leak-proof installation resulted when a sampling instrument or sensor was epoxied into the male 1.9 cm PVC adaptor which was wrapped w/Teflon tape and screwed into the female adaptor. After the installation of sensors and leachate collection lines had been completed, the interior surface of the male and female adapters were coated with coal-tar epoxy to produce an unbroken finish for the test cell interior.

Two of the ports at the soil-MSW interface were fitted with porous polypropylene filter candles through which the above soil leachate samples could be collected. The filter candles were epoxied into male adaptors and installed into the female adaptors as described above (see Figure 7). An alternative above-soil leachate collection apparatus was also installed in another soil-MSW interface port. A matrix of 1.9 cm PVC (schedule 40) pipe was installed at the soil surface. Perforated pipes drain into a central rib which exits through the cell wall; the total surface area of the matrix was about 600 sq. cm. These collectors would collect approximately 2 liters of leachate per month.

Thermisters were installed in the ports in a vertical line up the side of the test cells. Thermister leads from Yellow Springs Instruments (model 415 glass sensors) were inserted into an 8 cm length of 1.27 cm ID PVC pipe which was then filled with coal-tar epoxy. The shielded thermister leads were run through a 0.91 m length of Tygon tubing which was fixed to a male adaptor with epoxy and inserted into the port as described above. The thermister probes were taped to the inside of the tanks until the level of the wastes were even with the port when the probes were laid into the center of the test cell. Of the 35 thermisters installed in this manner, only 5 were rendered unusable by the tamping and loading operation. Thermister leads were routed to a 56 channel data logger and to a set of reference electronics. The data logger sequentially applied the reference voltage to each thermister and recorded the current flow. The current level was translated into temperature units by a microcomputer which had been previously calibrated.

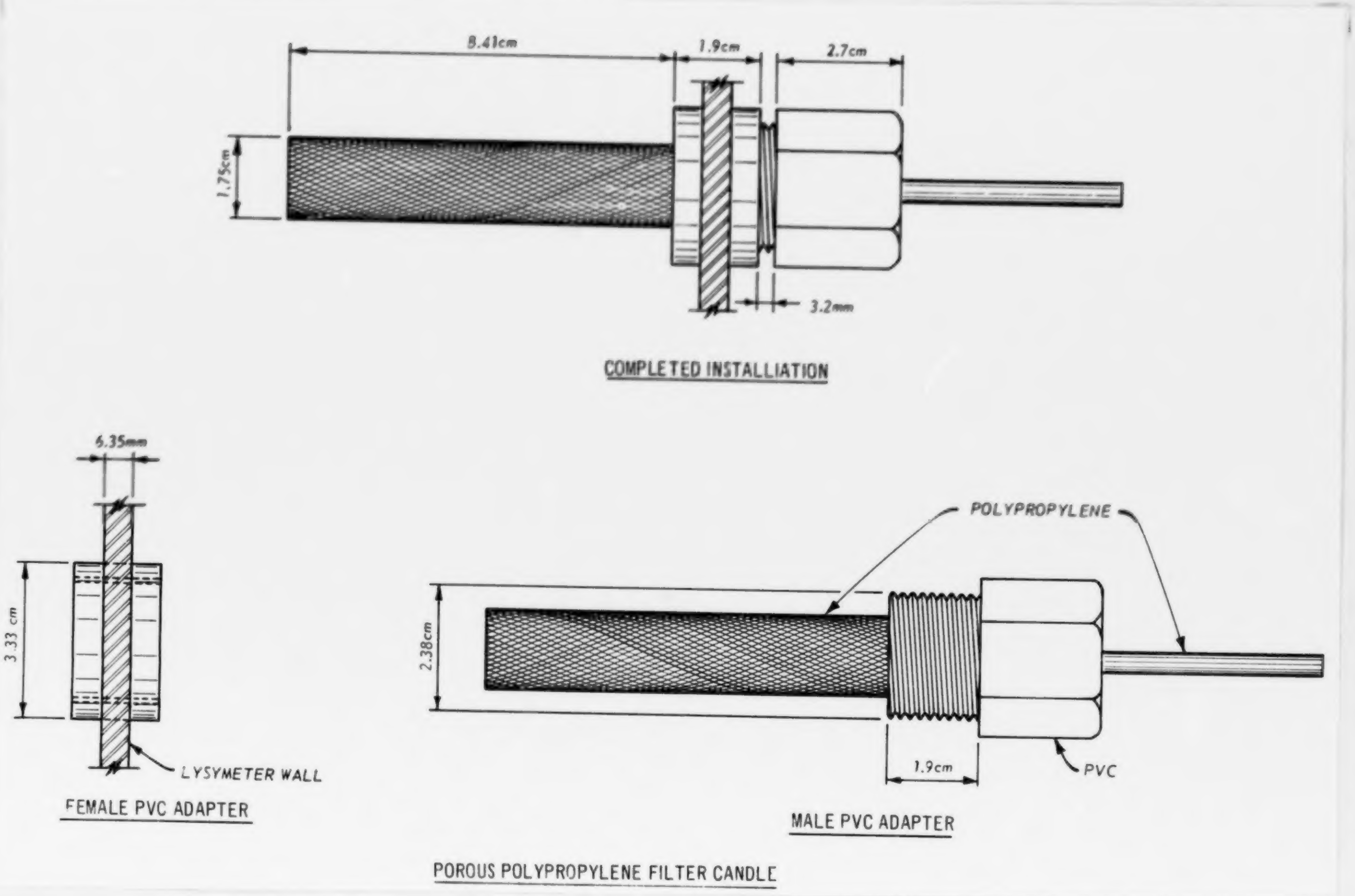
8.41cm
1.9cm
2.7cm
1.75cm
3.2mm
COMPLETED INSTALLIATION
6.35mm
3.33 cm
LYSYMETER WALL
FEMALE PVC ADAPTER
POLYPROPYLENE
2.38cm
1.9cm
PVC
MALE PVC ADAPTER
POROUS POLYPROPYLENE FILTER CANDLE

Figure 7. Above-soil leachate collectors.

The polypropylene filter candles were not installed in the four test cells containing MSW only because of possible gas leakage through them. The two smaller MSW only test cells had only one thermister installed.

Infiltration was produced by introducing purified water to the top of the test cells at an application rated of 1.27 cm per week (66 cm/year). The water purification and distribution system is shown in Figure 8. In the pressurized (1.76 kg/m^2) system, water was purified by passing sequentially through a carbon tank, two mixed-resin-bead deionizers, and a 0.2 mm pore size filter. An in-line conductivity meter continuously monitored the water quality from the purification system. Infiltration water consistently measured a resistance greater than 3 megaohms and had a pH of 6.3. It was distributed to all test cells through PVC pipe. At each test cell the leaching liquid passed through a PVC ball valve, a calibration needle valve, a port in the center of the cell lid and was distributed out through a PVC spray nozzle which delivered a full-cone pattern. The needle valves were calibrated to deliver 22.25 l/min at 1.76 kg/m^2 pressure so that a 90 second flow of water would deliver 33.4 l, or a 1.27 cm depth, of leaching medium for the large test cells during their weekly infiltration additions. Thus the average monthly leachate production by the large test cells should be near 140 l. The needle valves for the smaller (0.91 m diameter) test cells were set to allow a flow rate of 16.5 l/min so that a 30 sec flow would inject 8.25 l of leaching medium which is equivalent to 1.27 cm depth. The expected leachate production from the smaller cells should average about 36 l/month. The leaching medium was sprayed onto an 8 cm layer of washed pea gravel which was installed to help to distribute the leachant* and to prevent the erosion of the MSW by the sprayer. A general view of the large test cells before loading is shown in Figure 9.

Test Cell Loading and Profiles

Two large (#15 and 16) and the two small (#10 and 22) test cells contained only MSW. The remaining test cells contained two layers of treated or untreated IW interspersed between three layers of MSW for the co-disposal tests. The weight of the different waste materials loaded into each test cell are shown in Table 5. A typical profile showing the placement of the soil, treated IW/MSW and the washed gravel is shown in Figure 10 and a partially loaded test cell in Figure 11. The 30.5 cm soil layer was placed in the test cells at its natural moisture content (7%) and compacted in place to a wet density of 1766 kg/m^3. The MSW was placed in 30.5 cm lifts which were compacted to 400 to 415 kg/m^3 wet density with a 2315 kg lead weight (Figure 12). Each layer of chemically treated IW was made up of four cylindrical 61 cm. dia. cores of solidified/stabilized waste product. MSW was also packed around the treated IW cores and compacted to approximately the same wet density by use of a hand held tamper.

This loading of the test cells gives MSW-IW volume ratios of approximately 4 to 1 which is in the range recommended for the codisposal ratio of MSW to IW. This design exposes 1.75 m^2 of surface area of each treated IW core for a total of about 14 m^2 of exposed surface area for all 8 cores in each test cell containing treated waste. While the 250 kg treated IW cores do not exactly duplicate the final form in which the vendors place their treated wastes in their disposal areas, they are relatively large monolithic masses

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*Deionized water added to test cells.

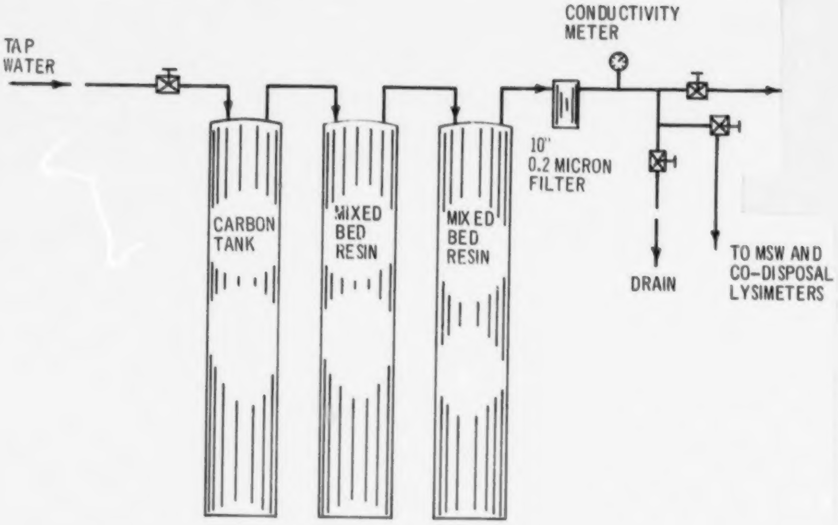
TAP WATER
CONDUCTIVITY METER
CARBON TANK
MIXED BED RESIN
MIXED BED RESIN
10" 0.2 MICRON FILTER
DRAIN
TO MSW AND CO-DISPOSAL LYSIMETERS

Figure 8. Water purification and distribution system.

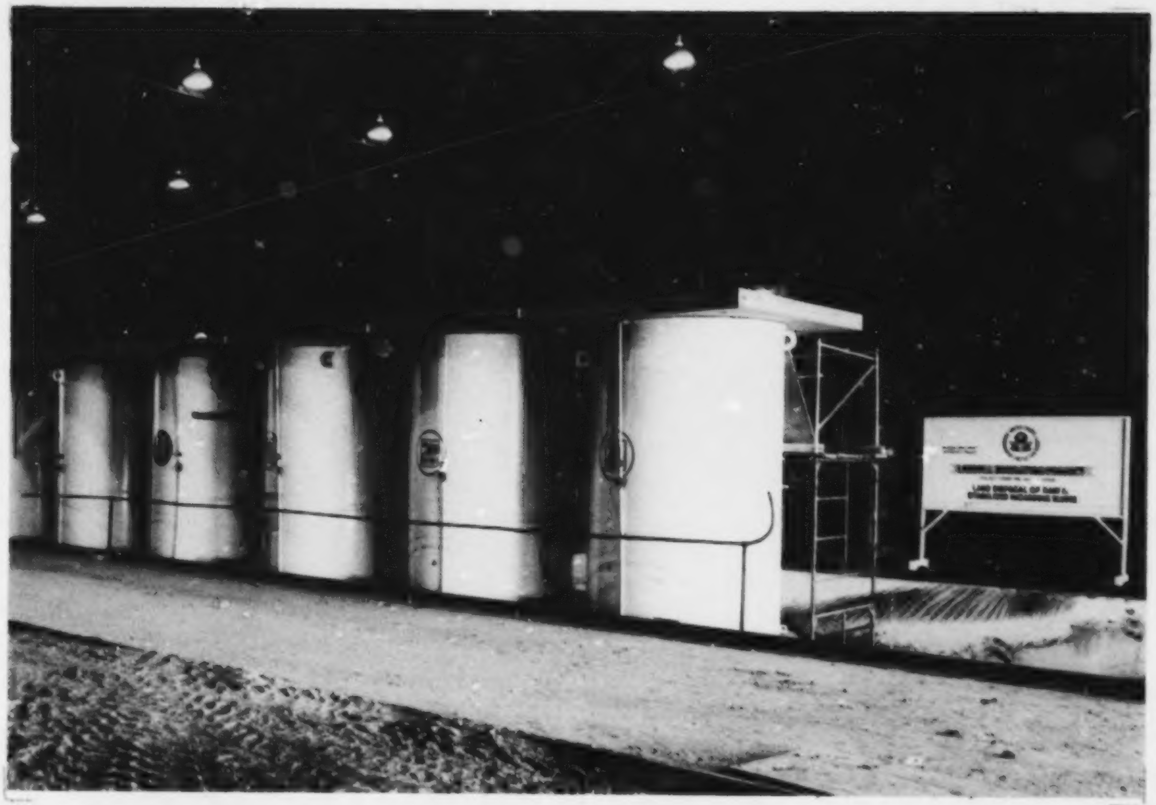

Figure 9. General view of large test cells just before loading.

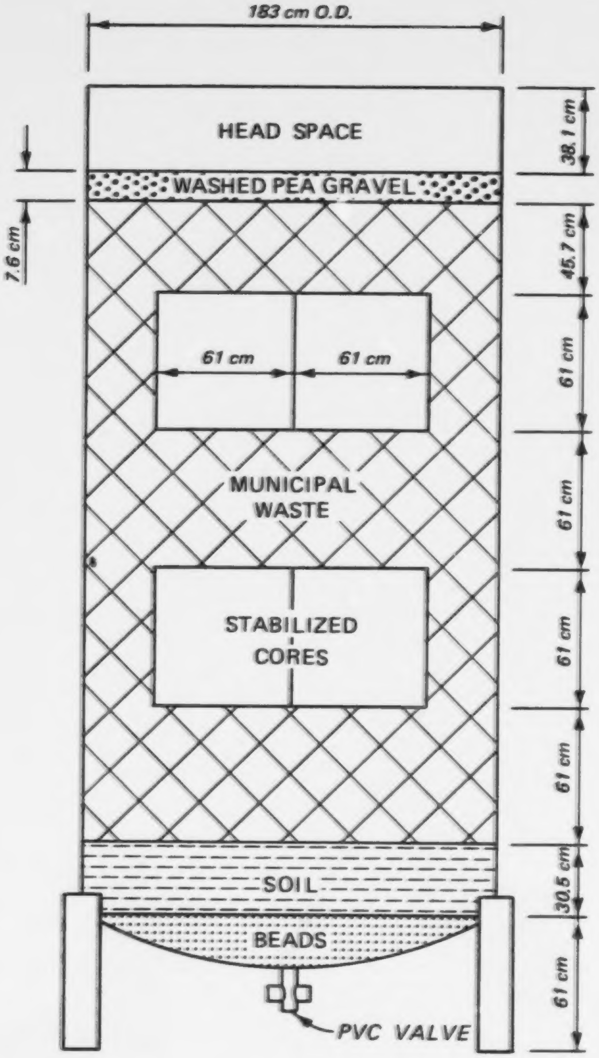
183 cm O.D.
HEAD SPACE
38.1 cm
WASHED PEA GRAVEL
7.6 cm
45.7 cm
61 cm
61 cm
61 cm
61 cm
61 cm
61 cm
MUNICIPAL WASTE
STABILIZED CORES
61 cm
SOIL
30.5 cm
BEADS
61 cm
PVC VALVE

Figure 10. Profile of test cell with treated industrial waste cores.

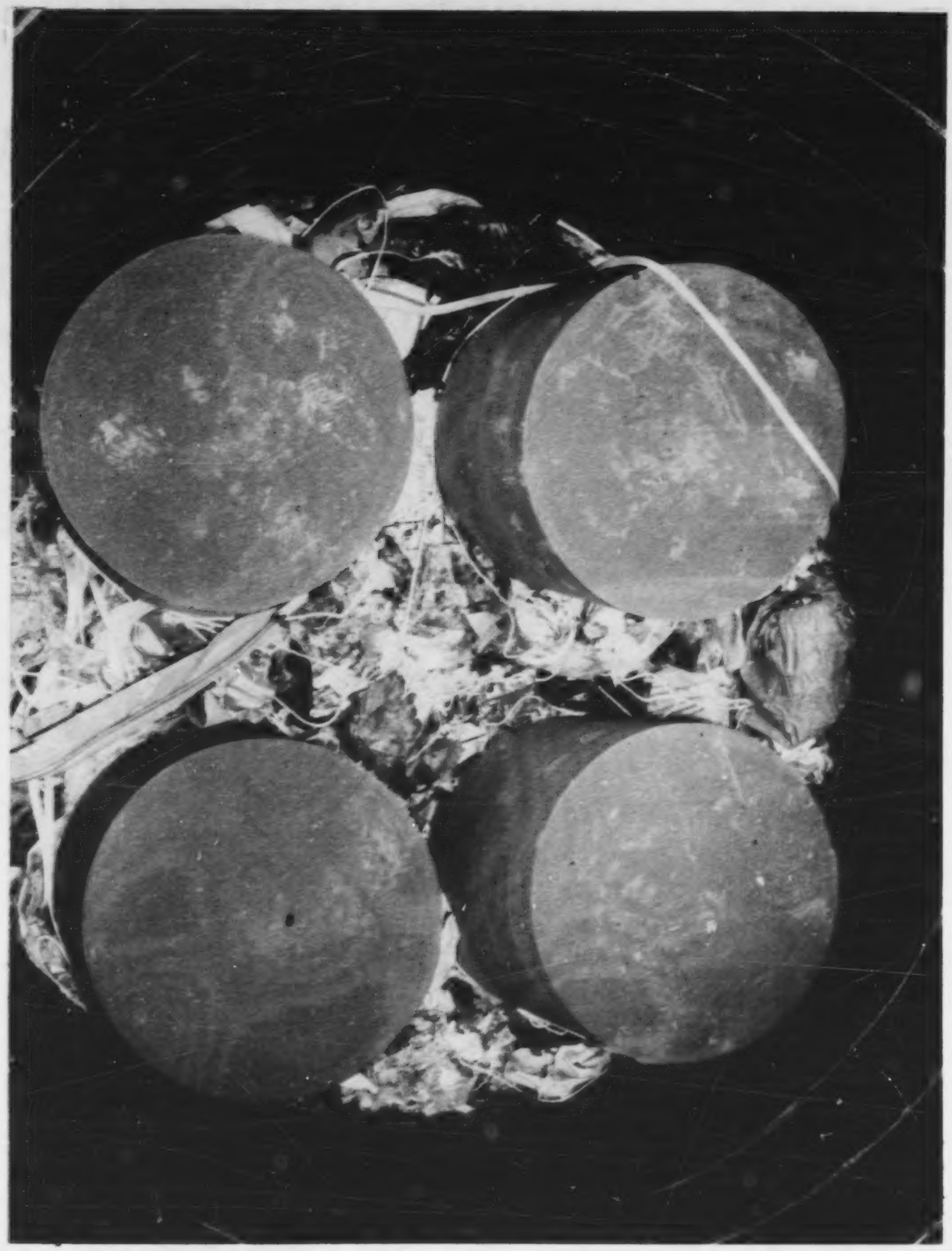

Figure 11. One layer of cores of solidified IW as loaded into test cells.

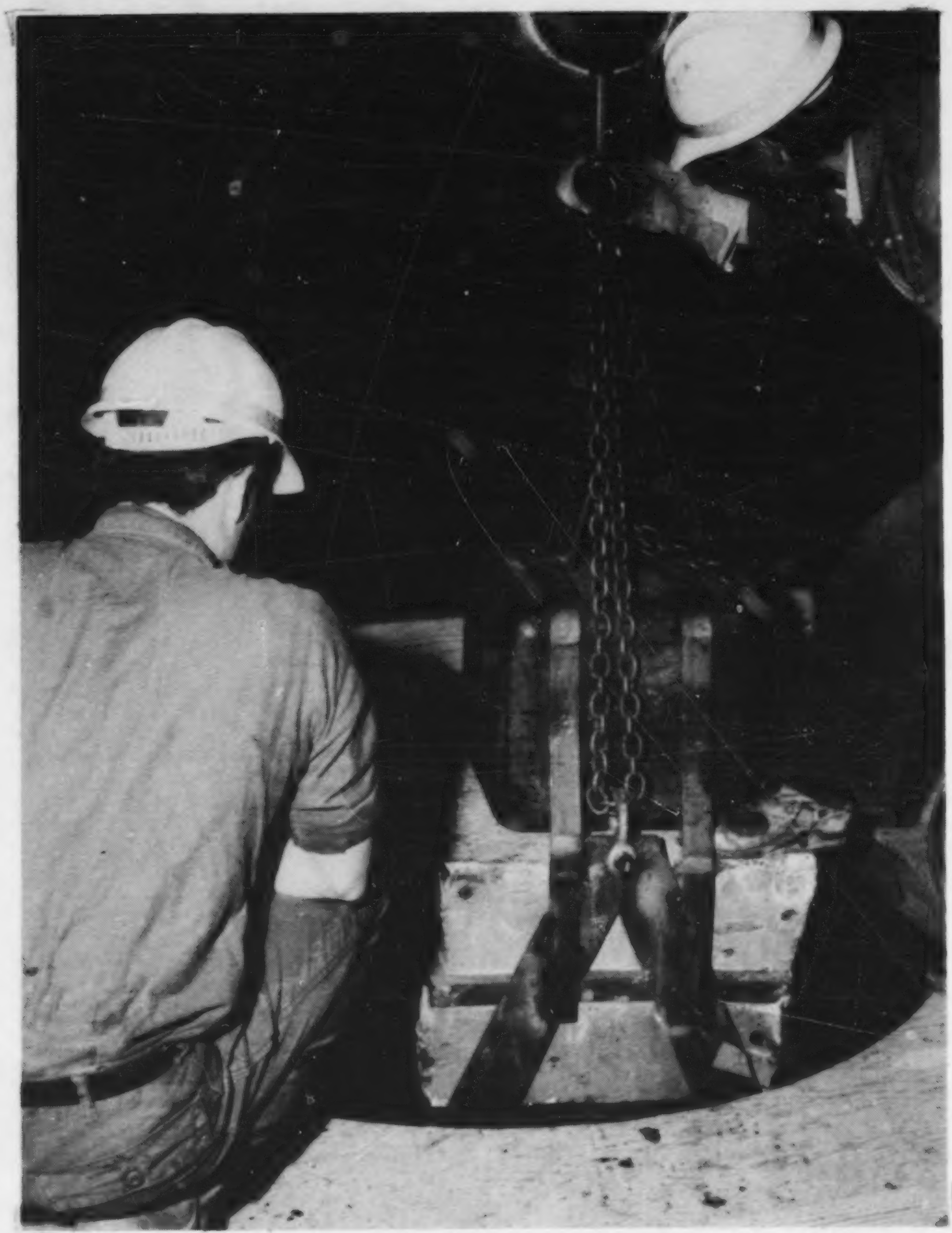

Figure 12. Compacting MSW with 2315 kg lead weight.

with reasonably small surface areas exposed. These cores are about as large as can be reasonably handled in typical landfill conditions.

The test cells containing untreated IW were loaded in the same way as those containing treated IW except that a complete layer of untreated sludge was introduced in place of the treated waste cores as shown in the profile in Figure 13. Untreated sludge of a weight calculated to be equivalent to 0.71 m^3 were added in each sludge layer over the tamped MSW making a total of 1.42 m^3 of untreated waste per test cell. The actual weight of dry sludge solids added to each cell is also shown in Table 5.

The MSW-only test cells were loaded at the same time and manner as those including IW. Figure 14 shows a weighed portion of waste being loaded into a large test cell. Profiles of the two sizes of MSW-only cells are shown in Figure 15. The smaller test cells contained about 1/8th the MSW as did their larger counterparts so that differences due to test cell scale could be evaluated. The MSW only test cells were also included in another study of the production of gases from landfilled MSW. For this reason, special gas probes were installed above the top gravel layer to monitor the gases being produced. These cells were hermatically sealed. The design and construction of the gas collection and analysis system is being reported separately. Preliminary results of these gas experiments have already been presented (18, 19) and a final report is being published (20).

The actual loading of all 13 test cells was accomplished in less than 72 hours from the first MSW delivery to the final sealing of the cells. A total of 27,807 kg of fresh MSW, 7315 kg of untreated and 13,487 kg of treated IW were procured, weighed, placed and compacted. Compaction to an average density of 400 to 415 kg/m^3 was achieved by repeatedly lowering a 2315 kg lead weight (Figure 12) with a bearing surface of 0.367 m2 on the loaded MSW (compaction load of about 6300 kg/m^2). The interiors of the test cells were graduated with chalk lines in 30.5 cm increments which are used to determine the correct placement and the compacted density of the preweighed waste.

LEACHATE COLLECTION, PRESERVATION AND PROCESSING

Careful handling of the leachate samples used in the analytical program was necessary to preserve the anaerobicity of the samples during sampling and before preservation. The sampling of the test cell leachates was accomplished using the apparatus (Figure 16) and procedures outlined below. This procedure was used for all quarterly samples. The smaller monthly samples could be subsampled and preserved rapidly enough to make the helium atmosphere unnecessary. Quarterly samples were drawn by suction from the test cells through Tygon tubing into a 500 ml, stoppered, glass aspirator bottle mounted on the glovebox. Leachate was than forced inside the glove box with helium pressure. The glovebox had previously been purged with helium for a minimum of 5 minutes. The subsamples as outlined in Table 6 were prepared within the glovebox without contacting atmospheric air. The subsamples were removed from the glovebox via an air-lock which was repurged with helium after each use. Biochemical and chemical oxygen demand subsamples were immediately analyzed in a mobile laboratory located near the test cell site. The alkalinity, conductivity and pH subsample was also analyzed immediately at the test cell site. The other five

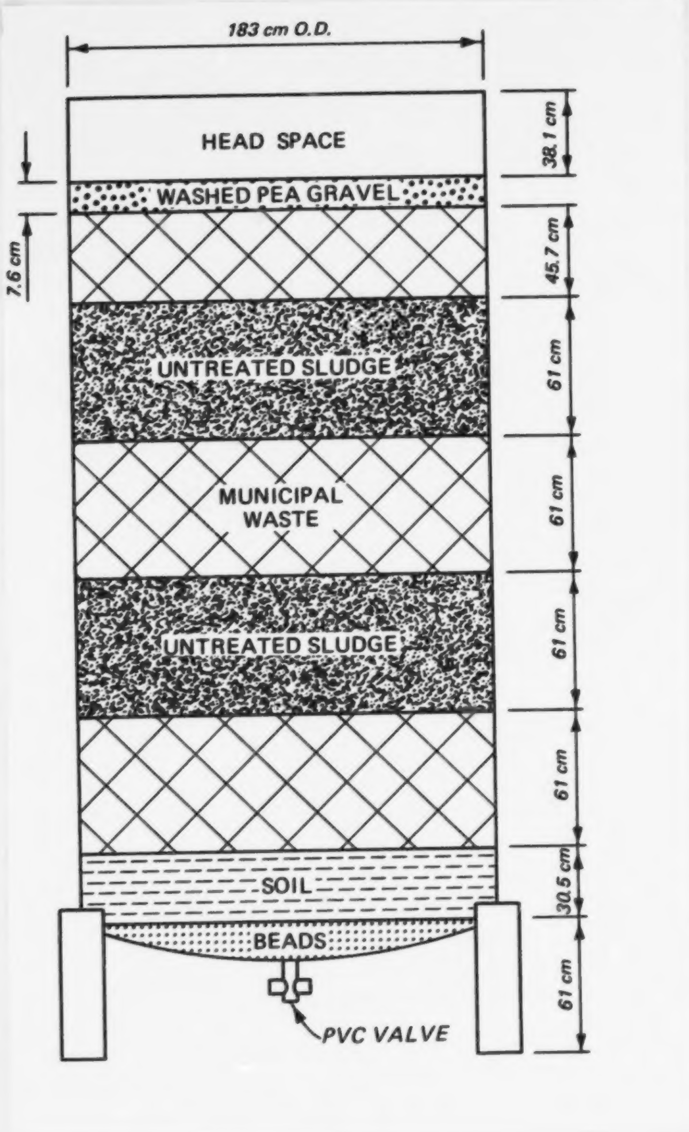
183 cm O.D.
HEAD SPACE
WASHED PEA GRAVEL
7.6 cm
UNTREATED SLUDGE
MUNICIPAL WASTE
UNTREATED SLUDGE
SOIL
BEADS
PVC VALVE
38.1 cm
45.7 cm
61 cm
61 cm
61 cm
61 cm
30.5 cm
61 cm

Figure 13. Profile of test cell with untreated waste.

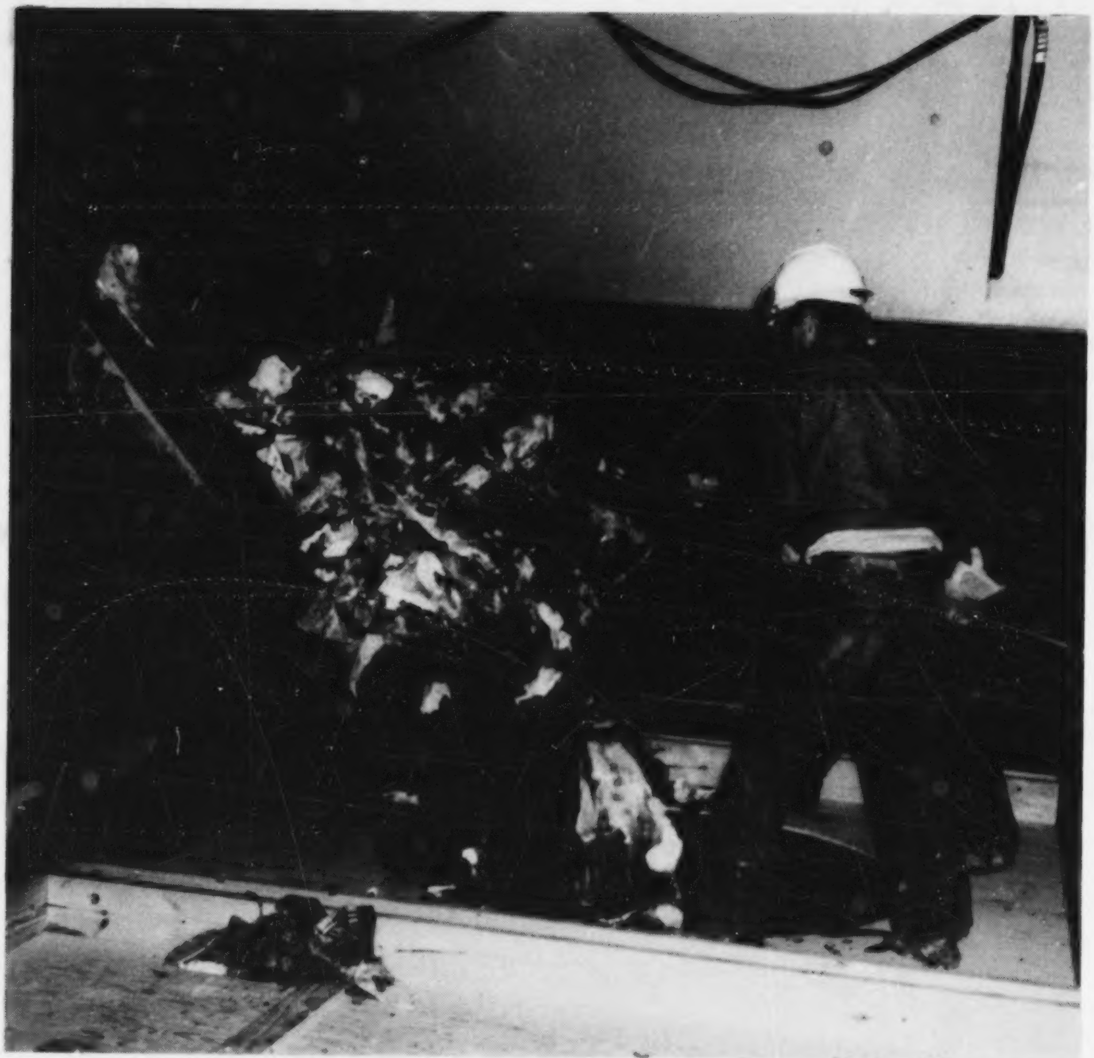

Figure 14. Preweighed MSW being loaded into large test cell.

TABLE 5. MSW, IW AND TREATMENT ADDITIVE TEST CELL CONTENTS

IW*	Process*	Test Cell No.	MSW (kg dry)	IW** (kg dry)	Sludge Solids (kg dry)***	Additive (kg dry)***
200	A	14	2038	1951	312	517
800	A	17	2036	2609	1020	652
900	A	18	2045	2026	608	547
200	B	11	2028	2317	359	1180
800	B	12	2043	2302	575	1220
900	B	13	2031	2282	234	1260
200	Untreated	19	2035	2200	704	None
800	Untreated	20	2041	2845	1678	None
900	Untreated	21	2039	2270	1303	None
(MSW Only, large)		15	2038	None	None	None
(MSW Only, large)		16	2096	None	None	None
(MSW Only, small)		10	264	None	None	None
(MSW Only, small)		22	261	None	None	None

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* See text for IW and process identity codes.

** Total weight of treated or untreated waste sample loaded into the test cell.

*** Calculated using percentages shown in Table 3.

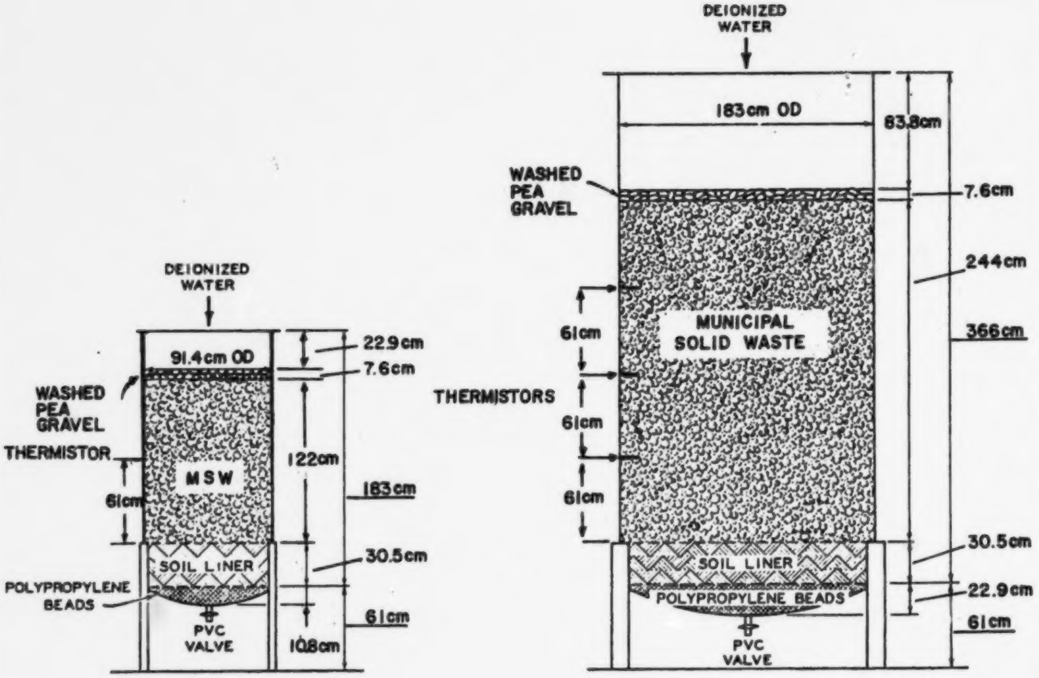
DEIONIZED WATER
91.4cm OD
22.9cm
7.6cm
WASHED PEA GRAVEL
THERMISTOR
6lcm
MSW
122cm
183cm
SOIL LINER
30.5cm
POLYPROPYLENE BEADS
PVC VALVE
6lcm
10.8cm
DEIONIZED WATER
183cm OD
83.8cm
WASHED PEA GRAVEL
7.6cm
244cm
MUNICIPAL SOLID WASTE
366cm
THERMISTORS
6lcm
6lcm
6lcm
SOIL LINER
30.5cm
POLYPROPYLENE BEADS
22.9cm
6lcm
PVC VALVE

Figure 15. Cross-section of large and small test cells.

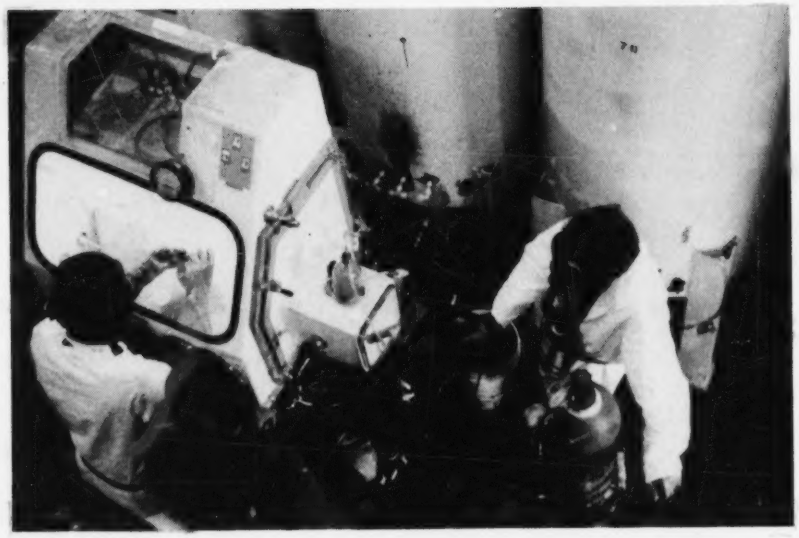

Figure 16. Leachate sampling hood.

TABLE 6. MONTHLY AND QUARTERLY LEACHATE SUBSAMPLING AND PRESERVATION METHODS

Parameter	Preparation and Preservation
MONTHLY AND QUARTERLY SAMPLING:	
Alkalinity, pH, and Conductivity.	Analyzed immediately, No preservatives.
Chloride	Analyze within 48 hr., No preservation.
Mercury	No preparation; Initiate analysis within 4 hr by sealing sample in digestion vessel.
Total Organic Carbon	No preparation; Initiate analysis within 4 hr by sealing sample in digestion ampule.
Metals*	Dilute 100 ml to 250 ml preserved with 2.5 ml or Ultrex nitric acid; analyze within 30 days.
QUARTERLY SAMPLES ONLY:	
Biochemical Oxygen Demand (5 day)	Dilute 1 ml to 500 using distilled water.
Chemical Oxygen Demand	Dilute 0.5 ml to 50 ml using distilled water.
Total Volatile Acids	Adjust to pH 2.0 using H_2SO_4 and bromthymol blue indicator; Store at 4C; analyze within 48 hr.
Fluoride	No preparation, analyze within 8 hr.
Total Kjeldal Nitrogen, Total Phosphate	Dilute 10 ml to 100 ml; preserve with 1 ml H_2SO_4; analyze within 48 hr.

NOTE: All quarterly samples collected and preserved under helium.

* Metals determined monthly were cadmium, chromium, iron and zinc; those determined quarterly were aluminum, arsenic, boron, beryllium, calcium, copper, lead, magnesium, manganese, nickel, potassium, selenium and sodium.

subsamples (metals, TKN-TP, total organic carbon, fluoride-mercury, and chloride-total volatile acids) were sealed and set aside for analysis at the WES Analytical Laboratory.

The analytical procedures used for each parameter are listed in Table 7. Replicate, spike and check samples were analyzed on a regular basis to establish quality control. Duplicate samples of total volatile acids, chloride, and chemical oxygen demand and triplicate determinations at three different dilutions were used for biochemical oxygen demand. The WES analytical laboratory participated in the U.S. EPA's audit program for metals, nutrients and oxygen demand parameters throughout the experimental period.

TABLE 7. METHODS OF ANALYSIS AND LIMITS OF DETECTION FOR ALL PARAMETERS.

Parameter	Procedures and/or instrumentation*	Lower reporting concentration (ppm)
Specific Conductance	YSI model 31 conductivity bridge	0.5 µmhos
ALK	Standard acid titration[†]	25
Cl	Destruction or organics using H_2SO_4 and H_2SO_4; filter; potentiometric titration with $AgNO_3$, Cl^- electrode, and Metrohm model E536 recording titrator[‡]	10
TKN	Technicon II Auto Analyzer, Industrial Method 376-75W/B and 32974W/B[#]	0.01
TP	Same as above	0.01
TOC	Determined with Oceanography International Corp. Model No. 0524B TOC Analyzer	1
Ca	Determined with a Spectrametrics Argon Plasma Emission Spectrophotometer Model II	0.03
Fe	Same as above	0.003
K	Same as above	0.05
Mg	Same as above	0.03
Mn	Same as above	0.001
Na	Same as above	0.03
Al	Same as above	0.01
As	Determined with a Perkin-Elmer Heated Graphite Atomizer Atomic Absorption Unit	0.001
B	Determined with a Spectrametrics Argon Plasma Emission Spectrophotometer Model II	0.02
Be	Same as above	0.005

(Continued)

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* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

[†] Standard Methods for the Examination of Water and Wastewater, American Public Health Association, New York, 14th Edition, 1975 (34).

[‡] Compilation of methodology for measuring pollution parameters of landfill Leachate. (See reference 31).

[#] Technicon Industrial Systems, Tarrytown, New York.

TABLE 7. (Concluded)

Parameter	Procedures and/or instrumentation*	Lower reporting concentration (ppm)
Cd	Determined with a Perkin-Elmer Heated Graphite Atomizer Atomic Absorption Unit	0.0003
Cr	Same as above	0.003
Cu	Same as above	0.003
Hg	Determined by standard cold vapor technique	0.0002
Ni	Determined with a Perkin-Elmer Heated Graphite Atomizer Atomic Absorption Unit	0.005
Pb	Same as above	0.002
Se	Same as above	0.005
Zn	Determined with a Spectrametrics Argon Plasma Emission Spectrophotometer Model II	0.014
BOD_5	Standard 5-day Biochemical Oxygen Demand, unseeded	2.0
COD	Standard dichromate/H_2SO_4 reflux†	50.0
TVA	Standard column partition chromatographic method	30.0
pH	Electrometric	--
F	Technicon II Auto Analyzer, Industrial Method 129-71-W	0.04

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† Standard Methods for the Examination of Water and Wastewater, American Public Health Association, New York, 14th Edition, 1975 (34).

SECTION 4

RESULTS OF LEACHING MUNICIPAL SOLID WASTE TEST CELLS

Analysis of the effects of the co-disposal of IW with MSW are dependent upon an understanding of the leaching characteristics of MSW and of the MSW leachate. In this section, the parameters of the MSW-only, test cell leachates are discussed. In the next section, comparison of the MSW-only leachates with those from the test cells containing MSW and untreated IW are discussed. This gives an understanding of interactions between the untreated IW and MSW leaching characteristics. These interactions are in turn compared with those found for the leachates from the test cells containing treated IW.

Aspects of the MSW leachate which might be expected to be changed by the presence of IW are those resulting from differences in biological activity in the MSW caused by toxicity or inhibition of the test cell flora by IW extractants, or from the addition of IW constituents to those already present in the MSW leachate such as COD, heavy metals or salts, or by changes in leachate parameters such as pH or oxidation-reduction potential. Thus the emphasis is first upon a complete analysis of the MSW-only test cell leachates from this study and their comparison with other landfill leachates as described in the literature.

WASTE MOISTURE RETENTION AND LEACHATE PRODUCTION RATES

Four test cells were loaded with MSW only--two small 0.91 m diameter (0.79 m^3) and two large 1.82 m diameter (6.34 m^3) cells--so that a reliable estimate of the parameters of the MSW leachate could be made. These two sizes were used to determine any effects of scale which might be present as the smaller size cells have been used in other studies (28). The larger cells, which had twice the diameter, contained approximately 8 times the weight of dry MSW solids (of Table 8), but received only 4 times as much leaching medium. The large cells therefore received about half as much leaching fluid per kg MSW (15.9 ml/kg MSW week) as the smaller cells (31.4 ml/kg MSW week).

To produce a 1.27 cm percolation of leachant per week, 8.25 l/wk of deionized water was added to each small test cell and 33.4 l/wk to the large test cells. The amount of leachate collected from the four MSW-only test cells at each sampling time is shown in Table 9 and a plot of the accumulated leachate volumes by days of leaching in Figure 17. The rates of leachate production remained relatively constant over the period of the experiment at about 28 l/month for the small and about 104 l/month for the large test cells even though there was considerable variation between the size of individual leachate samples. Since only a very small proportion of the total leachate (less than 1%) was removed in the above-soil samples, all calculations are based upon the assumption that equal amounts of leachate were produced above and below the soil layer.

The volume of leachant retained in the test cells is also shown for each monthly sampling period in table 9. These data are calculated simply as the volume of leachant added less the volume of leachate produced, and as such do not include the volume of water introduced in the initial MSW loading or any unmeasured spillage and/or evaporation. Moisture in the original MSW is estimated to be 38 ℓ for the small and 304 ℓ for the large cells (see Table 8).

TABLE 8. COMPARISON OF WATER BALANCE VALUES FOR SMALL AND LARGE MSW-ONLY TEST CELLS

Parameter	Small Test Cells	Large Test Cells
Volume of MSW (m^3)	0.79	6.34
Dry Weight MSW (kg)	262.5	2067.
Moisture in MSW (ℓ)	38.6	304
Leachate input (ℓ/week)	8.26	33.4
Total Leachate Produced in 1510 days leaching (ℓ)	1207.	4472.
(ℓ/kg dry MSW)	4.60	2.16
AVERAGE OVER 1ST 6 MONTHS OF CONSISTENT LEACHATE COLLECTION:		
Leachate Retained (ℓ)	288±14	1388±95
Total moisture in MSW:		
(ℓ/test cell)	326	1692
(ℓ/kg dry MSW)	1.23	0.822
Days estimated to first leachate	244±12	294±20

TABLE 9. LEACHATE VOLUMES PRODUCED AND RETAINED IN MSW-ONLY TEST CELLS

Sampling Day	Leachate Produced (ℓ)				Moisture retained (ℓ/kg dry MSW			
	Small cells		Large cells		Small cells		Large cells	
	(10)	(22)	(15)	(16)	(10)	(22)	(15)	(16)
247	72.8	76.0	234.4	156.1	0.82	0.82	0.46	0.48
282	0.0	0.0	0.0	0.0	0.98	0.98	0.54	0.56
303	59.8	38.2	92.7	81.7	0.85	0.93	0.54	0.57
331	0.0	0.0	0.0	0.0	0.97	1.05	0.61	0.63
359	54.1	54.5	166.9	153.3	0.89	0.97	0.59	0.63
388	39.9	39.5	122.0	127.3	0.87	0.95	0.60	0.63
437	36.7	49.2	152.9	147.2	0.95	0.98	0.64	0.67
458	0.0	0.0	0.0	0.0	1.04	1.08	0.69	0.72
486	33.3	36.7	135.1	127.9	1.04	1.07	0.69	0.72
514	42.0	35.2	145.7	176.4	1.01	1.06	0.68	0.70
542	35.0	34.6	130.0	72.2	1.00	1.05	0.68	0.73
570	34.1	31.4	127.6	117.0	1.00	1.06	0.69	0.74
598	33.7	33.3	151.4	138.6	1.00	1.06	0.68	0.74
633	42.8	39.0	95.0	173.0	0.99	1.07	0.71	0.73
664	39.0	31.8	132.1	119.6	0.98	1.08	0.72	0.75
689	40.1	34.5	129.3	115.3	0.94	1.06	0.72	0.75
724	41.3	63.2	120.6	119.9	0.94	0.98	0.74	0.77
752	15.1	19.7	105.9	119.6	1.01	1.03	0.75	0.78
780	24.6	21.2	124.9	117.3	1.04	1.08	0.76	0.79
815	28.4	24.2	51.9	106.0	1.09	1.14	0.81	0.82
843	31.8	27.6	123.8	109.8	1.09	1.16	0.82	0.83
878	35.2	31.0	99.2	118.1	1.12	1.20	0.85	0.85
906	27.6	28.4	103.0	84.8	1.14	1.22	0.87	0.87
934	29.9	29.5	100.3	77.2	1.15	1.23	0.88	0.90
969	45.0	33.7	155.9	96.5	1.14	1.26	0.89	0.93
1053	86.3	132.5*	303.1	447.8	1.18	(1.14)*	0.94	0.91
1150	20.6	65.1	252.4	251.0	1.54	(1.32)	1.04	1.01
1235	40.9	59.4	225.5	214.6	1.77	(1.48)	1.13	1.10
1328	47.4	38.5	224.9	248.4	2.00	(1.75)	1.24	1.20
1415	53.0	96.9	357.1	356.9	2.19	(1.78)	1.26	1.22
1510	51.2	67.7	275.8	330.9	2.42	(1.95)	1.35	1.28

* Cell 22 flooded on day 1053 when the valve stem sheared; unknown amount of leaching solution added.

NOTE: All values in ℓ or ℓ/kg dry MSW

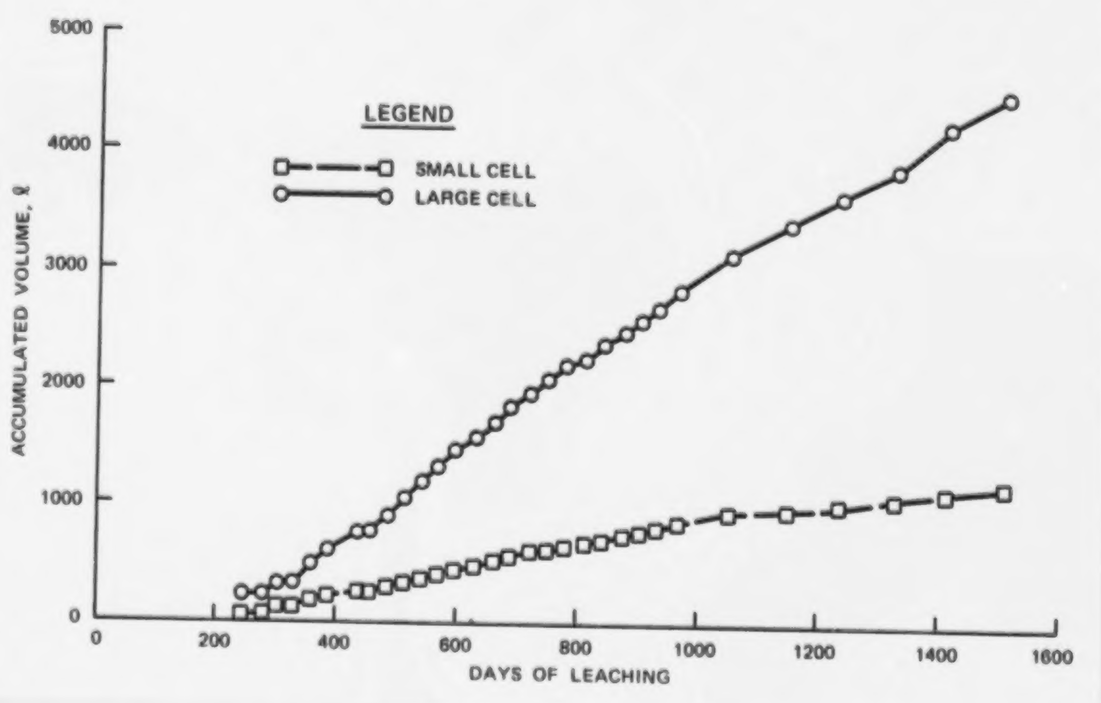

Figure 17. Plot of accumulated volume of leachate by days of leaching for test cells containing MSW only

The volume of leachant retained in the cells is quite uniform but tends to increase throughout the experiment especially after the first 8 to 12 months of leachate production.

Taking the average retained volumes for the 2nd to the seventh month of collection (for which very stable numbers are found), the initial volume of leachant retained in the test cells over this time period was 1235 ml/kg dry weight of MSW for the small cells (55% moisture), and 822 ml/kg for the large test cells (45% moisture) including the moisture added in the original MSW (14.7% of the dry weight or 147 ml/kg dry MSW). Maximum decomposition rates for freshly placed MSW were found at moisture contents between 50-70% (w/W), while older fills had maximal rates between 30 and 80% moisture (Pohland, 1975). Moisture levels in the MSW test cells in this study should have been near optimum for microbial stabilization.

The saturated moisture content of the MSW in this study which corresponds to its initial "field capacity" (6, 30) is 123.5% and 82.2% of the dry MSW solids for the small and large cells respectively. These compare closely to the field capacity of highly organic soils but are higher than found in typical inorganic soils. Clay soils, which typically have the highest field capacities of the inorganic soils, commonly have field capacities around 50% of the soil dry weight.

Reasons for this reproducible difference between the amount of leachant retained per kg MSW for the small and large test cells are not readily apparent. The nearly 50% larger moisture content of the saturated MSW in the smaller cells seems too large to be caused simply by differences in test cell wall effects or by differences in the leachant addition rates. It is possible that the higher leachant addition rate per kg MSW in the small test cells could cause an increased biological activity or decomposition rate which might account for the higher water retention.

The number of days before leachate should appear at the bottom of the test cells can be calculated from the addition rate and the field capacity of the MSW in the cells. For the small test cells this calculates to a number very close to that actually seen in the experiment (244 days compared to the 247 experimental days until the first collection was made). The appearance of leachate from the large test cells would be expected to be much later since the leachant addition rate per dry MSW was half that of the smaller cells; however the lower field capacity of the MSW in the large cells offset the lower addition rates so that the calculated time to first leachate is only about 20% longer than from the small cells. As the amount of water retained in the test cells (or field capacity) increased over the longer time period of the experiment, the small test cells continued to have significantly higher saturated percent moistures when compared to the large cell MSW (233% to 147% of the MSW dry weight at the end of the study, respectively). However, these long term calculations are subject to increasing error because the breakdown of the MSW over the 4 year leaching period would reduce the MSW mass, and evaporation and incidents of minor leakage or sampling error would become increasingly significant.

TABLE 10. pH-VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR ABOVE-SOIL SAMPLES ONLY

Sampling Day	Small Test Cell (10)	Large Test Cells		Large/Small Ratio*
		(15)	(16)	(15/10)
302	5.45	5.20	4.35	0.95
321	5.30	5.55	5.05	1.04
359	5.30	5.48	5.35	1.03
388	5.20	5.13	5.36	0.98
437	5.15	5.15	5.40	1.00
458	5.05	5.20	5.40	1.02
486	4.90	5.10	5.25	1.04
514	4.90	5.35	5.20	1.00
542	3.15	5.40	5.50	1.04
570	5.20	5.45	5.55	1.04
598	5.15	5.35	5.45	1.02
633	5.15	5.25	5.70	1.01
664	4.50	4.60	5.10	1.02
689	4.80	5.10	5.50	1.06
724	4.50	4.90	5.00	1.08
752	4.90	5.10	5.50	1.04
780	4.90	5.20	5.70	1.06
815	4.80	5.15	N	1.07
843	5.20	5.70	N	1.09
878	5.20	5.80	N	1.11
906	5.70	6.20	N	1.08
934	5.00	5.50	N	1.10
969	4.90	5.30	N	1.08
1053	5.10	5.30	N	1.02
1150	5.05	5.25	N	1.03
1235	5.60	5.30	N	0.94
1323	5.70	5.35	N	0.93
1415	5.80	5.35	N	0.92
1510	5.70	5.35	N	0.93
Mean*	5.14	5.31	5.33	1.03

NOTE: All values in standard units.
* Arithmetic means and ratios for comparison only.

Leachate pH

The pH values of leachates from all MSW only test cells were generally in the range of 4.9 to 5.5 as seen in Table 10 which shows the actual pH values for above soil samples measured for each sampling period in the experiment. The average pH values for the MSW leachates before passing through the soil were 5.14 for small test cell 10 and 5.31 and 5.33 for the large test cells, 15 and 16 respectively. The average pH values varied only slightly between test cells over the length of the study.

The pH values for the MSW-only leachates after passing through the soil layer are shown in Table 11. Little difference is seen between the small and large test cells, although the large test cells consistently were about 0.5 pH units more basic, especially leachates from test cell 16.

The below-soil-samples are compared with the above-soil-samples for both test cell 10 and 15 combined in the last column of Table 11. Differences between the above- and below-soil-samples are consistently less than 1% after the first few leachate samples were collected. The first few leachate samples were acidified slightly by their passage through the soil layer but the buffering capacity of the soil was quickly overcome so that the overall average difference between the above- and below-soil-samples was less than 0.1% by the end of the study.

Leachate Conductivities

The conductivity values for the leachates from the MSW only test cells are displayed in a similar manner in Table 12 for above soil samples. Conductivities represent a simple and reliable, but somewhat non-linear, measure of the ionic strength (concentration of dissolved salts and other charged material) of the leachate. As typical for leaching studies, the conductivities of the leachates from all test cells are high in the early leachate samples but decrease over the experimental period.

A very pronounced difference is evident in the above soil samples between the large and small test cells, as seen in the last column in Table 12 for above soil samples and 13 for below, and also in Figure 18. Although the leachate conductivities are comparable between the two sizes of test cells for the first few months of leachate collection, the conductivities of the small test cell leachates decrease more rapidly until they are consistently lower, ending at about half the values of the large test cell throughout the last two years of the study. These relative conductivity values should be accurate indicators of the relative ionic strength of the leachates. The lower conductivities of the leachates from the smaller test cells may result from the higher leachant addition per kg dry MSW, although the conductivities of leachate from both test cells sizes is remarkably stable from about day 500 throughout the experiment. Also, excellent agreement is seen between test cells of comparable size for both the above and below soil samples (averaging within 3% overall).

As seen in Table 13, the soil layer has no net effect on the conductivity of the leachates over the first 8 months of leachate collection--the above soil samples averaging 8470 and the below 8500 micromhms/cm. The mean values are compared for above and below soil samples for test cells 10 and 15 in the

TABLE 11. pH-VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR BELOW-SOIL SAMPLES AND RATIOS

Sampling Day	Small Test Cells		Large Test Cells		Ratios*	
	(10)	(22)	(15)	(16)	Lg/Sm	B/A**
303	5.00	5.65	5.30	5.40	1.00	0.96
331	5.25	5.45	5.20	5.30	0.98	0.96
359	5.40	5.50	5.29	5.30	0.97	0.99
388	5.30	5.43	5.13	5.10	0.95	1.00
437	5.25	5.42	5.19	5.31	0.98	1.01
458	5.15	5.20	5.20	5.30	1.01	1.00
486	5.00	5.20	5.00	5.40	1.02	1.00
514	5.10	5.35	5.25	5.40	1.02	1.01
542	5.20	5.45	5.35	5.65	1.03	1.00
570	5.20	5.45	5.40	5.70	1.04	0.99
598	5.15	5.50	5.45	5.85	1.06	1.01
633	5.20	5.35	5.40	5.95	1.07	1.02
664	4.70	4.90	4.80	5.30	1.05	1.04
689	4.90	5.20	5.00	5.50	1.03	1.00
724	4.70	4.90	4.90	6.90	1.22	1.02
752	4.90	5.10	5.20	5.70	1.09	1.01
780	5.00	5.20	5.20	6.00	1.09	1.01
815	4.85	5.10	5.10	5.65	1.08	1.00
843	5.10	5.50	5.40	5.80	1.05	0.96
878	4.50	5.70	6.00	5.30	1.10	0.95
906	5.80	5.90	6.00	6.70	1.08	0.99
934	4.90	5.00	5.40	6.10	1.16	0.98
969	5.00	4.90	5.10	5.70	1.09	0.99
1053	5.30	5.30	5.30	5.60	1.02	1.02
1150	5.05	5.00	5.20	5.65	1.07	0.99
1235	5.30	5.00	5.50	7.00	1.21	0.99
1328	5.40	5.25	5.85	5.60	1.07	1.02
1415	5.50	5.25	5.90	5.60	1.06	1.02
1510	5.40	5.25	5.85	5.60	1.07	1.01
Mean*	5.12	5.25	5.34	5.70	1.06	1.00

NOTE: All values in standard units.

* Arithmetic means and ratios for comparison only.

** Mean of below-soil values for test cells 10 and 15 divided by mean of above-soil samples for same test cells.

TABLE 12. CONDUCTIVITY VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR ABOVE-SOIL SAMPLES ONLY

Sampling Day	Small	Large Test Cells		Large/Small Ratio
	(10)	(15)	(16)	(15/10)
247	11000	9000	N*	0.01
303	9000	8800	6000	0.97
331	8500	8000	6700	0.94
359	9500	7000	7500	0.72
388	9500	8000	9000	0.84
437	6800	8100	7100	1.19
458	7800	8500	8000	1.16
486	7500	9000	8300	1.02
514	6000	9000	9800	1.50
542	5000	7100	9300	1.43
570	3500	5500	9500	1.57
598	4000	5500	7500	1.37
633	4200	5400	8500	1.23
664	3300	4700	7800	1.42
689	2800	3800	N	1.35
724	2500	4600	8400	1.84
752	2500	5300	8000	2.19
780	2200	3700	3300	1.68
815	3000	5200	N	1.73
843	3300	5700	N	1.72
878	3300	7800	N	2.26
906	2700	3800	N	1.40
934	2600	4000	N	1.53
969	2800	3800	N	1.33
1053	2500	4400	N	1.76
1150	3000	6000	N	2.00
1235	2900	5600	N	1.93
1328	3000	5200	N	1.73
1415	3000	5200	N	1.72
1510	3000	5200	N	1.72
Mean	4673	6096	7666	1.30

NOTE: All values in µmho/cm^2

* N = no sample available.

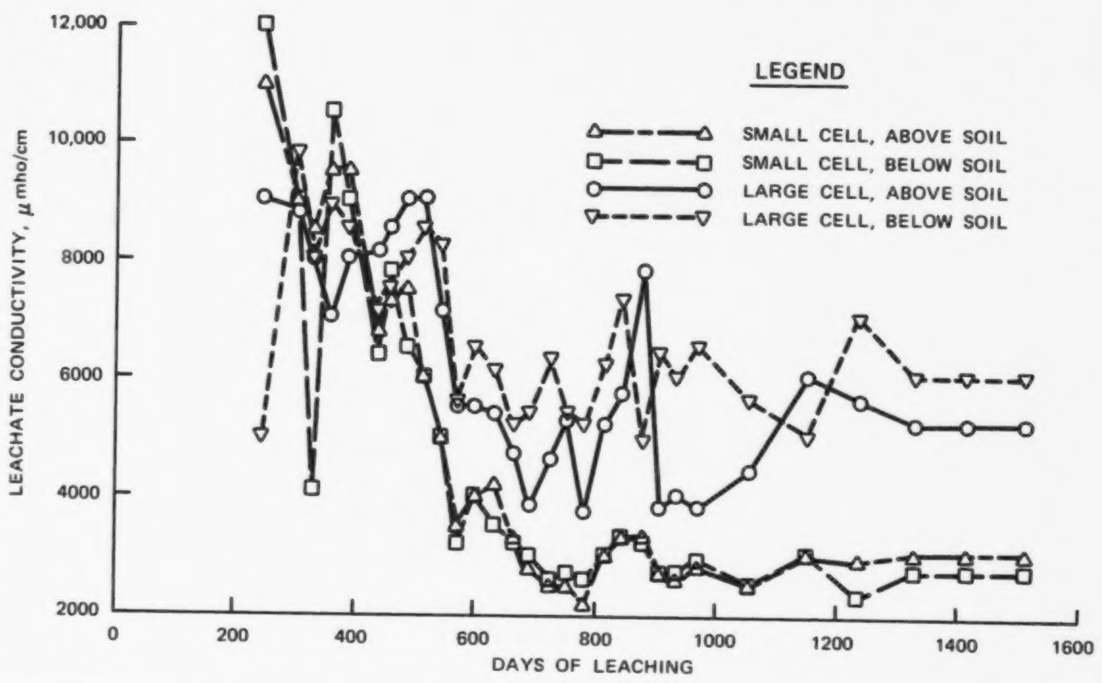

Figure 18. Plot of leachate conductivity by days of leaching for test cells containing only MSW.

TABLE 13. CONDUCTIVITY VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR BELOW-SOIL SAMPLES AND RATIOS

Sampling Day	Small Test Cells		Large Test Cells		Ratios	
	(10)	(22)	(15)	(16)	Lg/Sm	B/A*
247	12000	9500	5000	13000	0.83	0.85
303	9000	8700	9800	10000	1.11	1.05
331	4100	7100	8000	9400	1.55	0.78
359	10500	8500	8900	11000	1.04	1.17
388	9000	8000	8500	8500	1.00	1.00
437	6400	5900	7100	7900	1.21	0.90
458	7800	8500	7500	8500	0.98	0.96
486	6500	8500	8000	11000	1.26	0.87
514	6000	5000	8500	10000	1.68	0.96
542	5000	4800	8200	8500	1.70	1.09
570	3200	3200	5600	6400	1.87	0.98
598	4000	3500	6500	7500	1.86	1.10
633	3500	3500	6100	7200	1.90	1.00
664	3200	2800	5200	5800	1.83	1.05
689	3000	3100	5400	6600	1.96	1.27
724	2600	2500	6300	5900	2.39	1.25
752	2700	2700	5400	6100	2.12	1.04
780	2600	2500	5200	5600	2.11	1.32
815	3000	2600	6200	6900	2.33	1.12
843	3300	2800	7300	7400	2.40	1.18
878	3200	2900	4900	6700	1.90	0.73
906	2700	2800	6400	6400	2.32	1.40
934	2700	2400	6000	5200	2.19	1.32
969	2900	2900	6500	7200	2.36	1.42
1053	2500	2300	5600	5600	2.33	1.17
1150	3000	3000	5000	6000	1.83	0.89
1235	2300	2400	7000	6400	2.85	1.09
1328	2700	2100	6000	4900	2.27	1.06
1415	2700	2200	6000	4900	2.22	1.06
1510	2700	2100	6000	4900	2.27	1.06
Mean	4493	4293	6603	7350	1.59	0.97*

NOTE: All values in μmho/cm^2

* Mean below soil values for test cells 10 and 15 divided by the mean of above soil samples for same test cells.

last column of the table. After about day 650 until about day 1050, the below soil samples average 500 to 1000 micromhms/cm higher than the above soil samples. Evidently the ionic strength of the leachate over this time is increased by 20 to 30% by passage through the soil layer in the large test cell. However, the conductivity values when averaged for all samples are the same (within 3%) above and below the soil layer indicating that the soil layer has little or no long-term effect on leachate ionic strength.

CONCENTRATION OF LEACHATE CONSTITUENTS

The discussion of the amount of all parameters and constituents (except pH and conductivity) found in the MSW-only test cell leachates is based upon three different calculations for above-soil and below-soil samples: the overall (or mean) concentration in all leachates collected from each test cell (which is the arithmetic mean of the constituent concentration in all leachate samples), the highest concentration found in any leachate sample from that test cell, and the total mass of each constituent leached per kg dry MSW over the length of the study. This latter value is a summation for each sample of the concentration in mg/l times the volume of the sample in liters, all divided by the kg dry MSW loaded into that test cell. These parameters are shown in Tables 14 and 15 for the mean (overall) concentration, Tables 16 and 17 for the highest concentrations, and Tables 18 and 19 for the total mass of each constituent leached per kg dry MSW from above and below soil samples of the MSW-only test cells.

The levels of constituents found in the MSW-only test cell leachates are in line with those found in previous studies of landfill and MSW lysimeter leachates (7, 15, 31, 26). The leachates pose potential pollutant problems as the highest concentrations in above soil samples exceed drinking water standards (32, 33) for all constituents for which standards have been established (34) except copper. Most serious are iron and manganese which have mean leachate concentrations throughout the whole experiment of over 1000 and 100 times the standards, respectively. Other constituents which exceed these standards in mean concentrations are arsenic, chromium, selenium, zinc, and chloride. Further, very high concentrations of chemical and biochemical oxygen demand, total organic carbon, and total volatile acids are also found in all leachates. Patterns of constituent leaching also follows established form with high initial concentrations which decrease asymtotically over the length of the leaching period (Fig. 18). The levels of most constituents at the end of the 4 year leaching period are down to about 1/4 to 1/3 of their initial values. Only iron appears to violate this generalization, it's above soil concentrations showing increasing values to a broad peak or leveling off late in the study. The iron (and perhaps manganese) is apparently being solubilized by bacterial action, the rate of its reduction controlling it's leachate concentration.

The total mass in mg leached per kg dry MSW loaded into the test cell for all constituents is given in Tables 18 and 19. From 0.5 to 2 grams per kg MSW of calcium, iron, potassium, sodium, and chloride were lost from all cells over the 1510 day leaching period. Ten or more mg/kg MSW of boron, magnesium, manganese, and zinc were leached from the MSW. Also 25 to 70 grams of chemical oxygen demand equivalent have appeared in the leachate per kg of MSW loaded into the cells. The leachates also were high in organic nitrogen lost.

TABLE 14. MEAN CONCENTRATION OF METALS LEACHED OVER EXPERIMENT DURATION FOR TEST CELLS CONTAINING MUNICIPAL SOLID WASTES ONLY

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					Ratio*
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	Below/ Above
Aluminum	0.684	0.459	0.67	1.444	0.659	1.706	2.669	2.08	2.75
Beryllium	N	N	N	0.027	0.022	0.014	0.017	0.62	N
Cadmium	0.0029	0.0039	1.36	0.0113	0.0023	0.0041	0.0034	0.54	2.26
Chromium	0.053	0.128	2.41	0.132	0.039	0.100	0.094	1.13	1.28
Copper	0.011	0.10	0.89	0.016	0.014	0.012	0.010	0.74	1.26
Iron	399.757	323.527	0.80	425.	323.	396.	529.	1.23	1.13
Lead	0.017	0.036	2.09	0.051	0.014	0.016	0.031	0.73	1.24
Manganese	6.696	10.010	1.49	8.540	5.761	11.91	9.624	1.50	1.22
Mercury	0.0013	0.0010	0.83	0.0038	0.0014	0.0029	0.0022	0.97	2.90
Nickel	0.085	0.229	2.69	0.127	0.152	0.236	0.238	1.70	1.15
Selenium	0.047	0.104	2.20	0.086	0.040	0.071	0.100	1.35	1.03
Zinc	9.217	7.905	.85	13.41	3.752	8.244	3.665	0.69	1.26

NOTE: All values except ratios in mg/l. N = No or insufficient data.

* Test cells 10 and 15 only.

TABLE 15. MEAN CONCENTRATION OF OTHER PARAMETERS LEACHED OVER EXPERIMENT-DURATION FROM TEST CELLS CONTAINING ONLY MUNICIPAL SOLID WASTES

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					Ratio*
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	Below/ Above
Calcium	515.	520.	1.01	586.	466.	618.	529.	1.09	1.16
Magnesium	59.54	86.94	1.46	75.02	56.06	105.77	114.16	1.68	1.23
Potassium	246.	326.	1.32	245.	277.	395.	456.	1.80	1.12
Sodium	245.	377.	1.54	322.	216.	535.	602.	2.11	1.37
Arsenic	0.482	0.085	0.17	0.158	0.040	0.045	0.052	0.48	0.35
Boron	2.574	2.386	0.92	2.487	2.986	2.820	4.001	1.24	1.07
Chloride	379.	567.	1.49	397.	257.	672.	784.	2.22	1.13
Fluoride	0.212	0.156	0.73	0.353	0.287	0.347	1.223	2.45	1.90
Chemical Ox Dem	15537.	18385.	1.18	17182.	14267.	23216.	25746.	1.56	1.19
Biochem. Ox Dem	10293.	11922.	1.16	11885.	8533.	12183.	15810.	1.37	1.08
Tot Org Carbon	5157.	6004.	1.16	5018.	3815.	7145.	7227.	1.63	1.09
Alkalinity	1648.	2642.	1.60	1593.	1545.	2555.	2861.	1.73	0.97
Amine Nitrogen	357.	542.	1.52	348.	304.	633.	721.	2.08	1.09
Total Phosphate	22.29	22.65	1.02	6.83	7.22	3.14	6.04	0.65	0.22
Volatile Acids	1041.	1281.	1.23	765.	1366.	1709.	2271.	1.87	1.07
Volume (L)	36.8	143.2	3.90	36.8	41.0	143.2	145.3	3.70	1.00

NOTE: All values except ratios in mg/1.

* Test cells 10 and 15 only.

TABLE 16. HIGHEST CONCENTRATION OF METALS LEACHED OVER EXPERIMENT-DURATION FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTES ONLY

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	Ratio* Below/ Above
Aluminum	2.310	2.000	0.86	9.470	3.450	14.900	31.800	3.61	5.65
Beryllium	N	N	N	0.058	0.030	0.017	0.020	0.46	N
Cadmium	0.0189	0.0219	1.15	0.1297	0.0088	0.0185	0.0235	0.30	3.63
Chromium	0.243	0.338	1.39	1.80	0.141	0.361	0.387	0.38	3.71
Copper	0.025	0.038	1.20	0.055	0.053	0.040	0.037	0.71	1.72
Iron	1110.	713.	0.64	835.000	915.000	1470.000	840.000	1.32	1.26
Lead	0.070	0.158	2.25	0.354	0.039	0.052	0.127	0.45	1.78
Manganese	22.5	18.6	0.82	45.5	19.4	23.1	26.5	0.76	1.66
Mercury	0.0043	0.0023	0.53	0.0088	0.0068	0.0055	0.0113	1.07	2.16
Nickel	0.448	0.483	1.07	0.888	0.443	0.468	0.638	0.83	1.45
Selenium	0.068	0.160	2.35	0.170	0.040	0.125	0.135	1.23	1.29
Zinc	32.5	21.7	0.66	73.5	7.45	19.0	19.1	0.47	1.70

NOTE: All values in mg/l.
* Test cells 10 and 15 only.

TABLE 17. HIGHEST CONCENTRATION OF OTHER PARAMETERS LEACHED FROM TEST CELLS CONTAINING ONLY MUNICIPAL SOLID WASTES

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					Ratio*
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	Below/ Above
Calcium	1677.	1117.	0.67	2550.	1002.	1372.	1530.	0.80	1.40
Magnesium	265.	177.	0.67	467.	198.30	222.30	312.50	0.80	1.56
Potassium	1160.	592.	0.51	920.	847.	787.	1220.	1.13	0.79
Sodium	1225.	942.	0.77	2230.	1015.	1142.	1575.	0.84	1.56
Arsenic	4.350	0.280	0.06	0.975	0.063	0.140	0.132	0.26	0.24
Boron	13.9	8.090	0.58	12.40	12.30	8.740	14.80	0.95	0.96
Chloride	1295.	1063.	0.82	1854.	960.	1322.	1491.	1.00	1.35
Fluoride	1.100	0.349	0.31	1.400	0.787	0.775	8.12	4.06	1.50
Chemical Ox Dem	44800.	32600.	0.73	71700.	59800.	66800.	76300.	1.09	1.79
Biochem. Ox Dem	33000.	25000.	0.76	49500.	31000.	32000.	50000.	1.02	1.41
Tot Org Carbon	24500.	12000.	0.49	25500.	11000.	13500.	24000.	1.03	1.07
Alkalinity	4150.	8000.	1.93	4150.	3800.	5200.	4470.	1.22	0.77
Amine Nitrogen	1380.	881.	0.64	1330.	1140.	966.	1710.	1.08	1.02
Total Phosphate	40.90	31.40	0.77	14.70	15.90	4.90	9.50	0.47	0.27
Volatile Acids	4510.	3715.	0.82	3410.	10500.	9740.	18600.	2.04	1.60

NOTE: All values except ratios in mg/1.
* Test cells 10 and 15 only.

TABLE 18. TOTAL MASS OF METALS LEACHED PER KG DRY MSW FOR TEST CELLS CONTAINING MUNICIPAL SOLID WASTES ONLY

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	Ratio* Below/ Above
Aluminum	3.033	0.915	0.30	6.894	2.755	3.030	3.118	0.63	2.51
Beryllium	N	N	N	0.025	0.014	0.007	0.013	0.50	N
Cadmium	0.0075	0.0072	0.95	0.0593	0.0102	0.0073	0.0050	0.17	4.52
Chromium	0.228	0.242	1.06	0.842	0.192	0.196	0.161	0.34	2.20
Copper	0.041	0.015	0.37	0.053	0.034	0.018	0.013	0.35	1.26
Iron	1821.	779.	0.42	1962.	1605.	1007.	1112.	0.59	1.14
Lead	0.049	0.054	1.10	0.128	0.036	0.022	0.042	0.38	1.47
Manganese	31.3	21.8	0.69	39.980	28.452	25.886	19.373	0.66	1.23
Mercury	0.0014	0.0005	0.35	0.0053	0.0025	0.0018	0.0016	0.43	3.75
Nickel	0.425	0.505	1.18	0.580	0.776	0.522	0.481	0.74	1.18
Selenium	0.060	0.057	0.93	0.083	0.012	0.031	0.025	0.58	0.97
Zinc	42.0	14.7	0.35	67.5	17.2	15.13	6.652	0.25	1.45

NOTE: All values except ratios in mg leached/kg dry MSW.

* Test cells 10 and 15 only.

TABLE 19. TOTAL MASS OF OTHER PARAMETERS LEACHED PER KG DRY MSW FROM TEST CELLS CONTAINING ONLY MUNICIPAL SOLID WASTES

	MSW-ONLY TEST CELLS								
	Above Soil			Below Soil Samples					Ratio* Below/ Above
	Small 10	Large 15	Ratio 15/10	Small 10	Small 22	Large 15	Large 16	Ratio Lg/Sm	
Calcium	2473.	1117.	0.45	2791.	2161.	1338.	1040.	0.48	1.15
Magnesium	290.	189.	0.65	361.	263.	230.	228.	0.73	1.23
Potassium	1248.	723.	0.58	1281.	1167.	876.	939.	0.74	1.09
Sodium	1232.	838.	0.68	1586.	1089.	1178.	1219.	0.90	1.34
Arsenic	1.728	0.102	0.05	0.783	0.119	0.046	0.095	0.15	0.45
Boron	12.56	4.94	0.39	12.06	14.0	5.83	7.52	0.51	1.02
Chloride	1283.	995.	0.78	1408.	955.	1175.	1433.	1.10	1.13
Fluoride	0.676	0.191	0.28	1.501	0.986	0.471	0.978	0.58	2.27
Chemical Ox Dem	69365.	38405.	0.55	75341.	65402.	50151.	51894.	0.73	1.16
Biochem. Ox Dem	51318.	25203.	0.49	56160.	44841.	26581.	32087.	0.58	1.08
Tot Org Carbon	19560.	10471.	0.54	19512.	14637.	12164.	11999.	0.71	1.05
Alkalinity	6733.	5849.	0.87	6469.	6721.	5328.	5996.	0.86	0.94
Amine Nitrogen	1779.	1191.	0.67	1729.	1619.	1401.	1402.	0.84	1.05
Total Phosphate	109.01	50.13	0.46	26.40	24.82	5.45	11.58	0.33	0.20
Volatile Acids	3535.	2387.	0.68	3468.	5068.	3931.	5459.	1.10	1.25

NOTE: All values in mg leached/kg dry MSW.
* Test cells 10 and 15 only.

Of the metals assayed, 1 to 3 kg of calcium, iron, potassium, and sodium has been leached from the large test cells; also lost in gram quantities are boron (over 10 g), manganese (over 30 g) and zinc (25 g). About 2 kg of chloride and organic nitrogen (TKN) are found in the leachates from the MSW.

Total Organic Carbon

Appreciable amounts of organic carbon were lost as dissolved organic compounds (TOC) in the leachates--over 4 kg (15 g/kg dry MSW) of organic carbon from the small test cells, and 15 to 18 kg (7 to 8 g/kg dry MSW) from the large test cells. This is about 1% of the original MSW dry weight loaded into the test cells. If the MSW is assumed to consist of about 20% organic carbon then between 4 and 7.5% of the organic carbon originally loaded into the test cells has been leached. Both small and large test cells lost an average overall 4.5 to 4.7 g of TOC per liter of leachate produced over the entire experiment.

Total organic carbon (TOC) levels in the MSW-only leachates follows patterns similar to those of leachate conductivities discussed above. TOC levels have high initial values which rapidly drop to lower, relatively stable levels after two or three years of leaching (see Tables 20 and 21). Early samples from the large test cells appear to be similar to, or even lower than, those from the smaller test cells. However, the large test cells soon overtake the small cell leachates having consistently higher TOC concentrations after a year or two of leaching. The TOC levels average 20% higher overall in the two above- soil test cells for which leachates samples are available, and 76% higher when below soil samples from all four MSW-only test cells are compared (5th column of table 21). These higher TOC levels in leachates from the larger test cells probably reflect the same cause as the higher conductivities, that is, a lower dilution rate due to the lower volumes of leachate added per kg dry MSW solids. The lower leachate production per unit dry MSW means that the leachate which is produced will tend to be stronger.

Total organic carbon levels below the soil layer are slightly, but consistently, higher (by about 10%) than those taken above the soil layer (comparing only test cells 10 and 15). Evidently the 30.5 cm layer of sandy soil has very little effect upon the TOC load of the MSW-only leachates. The microbial action in the soil layer does not appreciably affect its organic loading.

Chemical (COD) and Biochemical (BOD) Oxygen Demand

The large organic carbon load in the MSW leachates is also evident in the large chemical and biochemical oxygen demands (COD and BOD) of the leachates. The mean oxygen demand requirements of leachate are about 15-18 g/ℓ chemical oxygen demand and 10-12 g/ℓ biochemical oxygen demand for both the small and the large test cells (Table 22). The relationships between the COD, BOD, and TOC for the MSW-only test cells are calculated for the total masses leached over the entire experiment in Table 23. The overall ratio of COD to TOC is over 3.0 as is typical of such wastes (31) meaning that 3-4 mg of oxygen is required for each mg of organic carbon contained in the leachates. This value is higher than would be expected for purely organic carbon loadings consisting

TABLE 20. TOTAL ORGANIC CARBON VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR ABOVE-SOIL SAMPLES ONLY

Sampling Day	Small	Large Test Cells		Large/Small Ratio
	(10)	(15)	(16)	(15/10)
247	24500	12000	N*	0.49
331	12000	9000	9500	0.75
388	10600	8850	10100	0.83
437	8500	9200	9800	1.09
458	6400	7200	8200	1.12
514	4000	7000	8200	1.75
542	4600	5700	9900	1.24
570	4100	7200	9750	1.76
598	5200	8600	9600	1.65
633	3750	4960	N	1.32
664	3520	5720	10700	1.82
689	3450	4400	9480	1.27
724	4100	6700	10300	1.63
752	3300	6500	11000	1.97
780	6600	N	10250	N
815	2000	4900	N	2.45
843	3280	4400	N	1.24
878	3080	4400	N	1.42
906	3040	4150	N	1.36
934	3460	4090	N	1.19
969	2750	3270	N	1.18
1053	2300	4100	N	1.78
1150	1900	3400	N	1.78
1235	2100	4100	N	1.95
1328	2640	3840	N	1.45
1415	2915	6430	N	2.20
Mean	4982	6004	9760	1.20

* N = No sample or data.

TABLE 21. TOTAL ORGANIC CARBON VALUES FOR LEACHATES FROM MSW-ONLY TEST CELLS FOR BELOW-SOIL SAMPLES ONLY

	Small Test Cells		Large Test Cells		Ratios	
Day	(10)	(22)	(15)	(16)	Lg/Sm	B/A*
247	25500	11000	13500	24000	1.02	1.06
331	11000	9300	11000	12400	1.15	1.04
388	9450	7800	9000	11000	1.15	0.94
437	8000	6800	8600	11000	1.32	0.93
458	5100	5900	7500	8700	1.35	1.00
514	3500	4350	8200	8400	2.11	1.06
542	4550	3200	8850	6900	2.03	1.30
570	4800	3500	7200	7400	1.75	1.06
598	8200	4500	10700	7500	1.70	1.22
633	4100	3250	4110	4010	1.10	0.94
664	3420	3000	6780	7820	2.27	1.10
689	3530	2900	6450	6700	2.04	1.27
724	4300	3600	8200	7600	2.00	1.15
752	3600	2700	7100	6200	2.11	1.09
780	3300	N**	N	5400	N	N
815	2700	1400	6400	2700	2.21	1.31
843	2950	2100	5900	5000	2.15	1.15
878	2900	2280	7350	5550	2.49	1.37
906	2880	2300	6560	5090	2.24	1.31
934	3380	2900	6380	5850	1.94	1.29
969	3110	2560	6000	6800	2.25	1.51
1053	2500	2400	5550	4600	2.07	1.25
1150	1600	1600	3100	4200	2.28	0.88
1235	1900	2115	4200	3700	1.96	0.98
1328	2350	1920	4210	4425	2.02	1.01
1415	2850	2000	5790	4975	2.21	0.92
Mean	5020	3115	7145	7230	1.76	1.11

NOTE: All values in mg/l.

* Mean below-soil concentrations for test cells 10 and 15 divided by the mean of above-soil samples for same test cells.

** N = no sample or data.

TABLE 22. CHEMICAL AND BIOCHEMICAL OXYGEN DEMAND, TOTAL VOLATILE ACIDS AND ALKALINITY OF ABOVE-SOIL, MSW-ONLY LEACHATES

Sample	Small Test Cell (10)				Large Test Cell (15)			
Day	COD	BOD	TVA	ALK	COD	BOD	TVA	ALK
247	44800	32000	N*	N	N	25000	N	N
331	41800	33000	306.	3800	32600	24500	2007.	3000
437	26000	16000	310.	2330	32280	18000	211.	2560
514	22400	8250	24.	1300	32370	16000	39.	2400
598	12200	22000	417.	1300	16900	25000	497.	1900
689	5890	4250	1420.	650	9400	5750	1560.	1050
780	7200	3000	970.	350	11700	5250	1090.	900
878	9500	5000	3450.	2130	11250	11500	N	4470
969	9900	5500	483.	639	9800	3500	426.	8000
1053	N	4750	520.	1400	12900	6000	3630.	2250
1150	6930	3900	1460.	2060	13500	1020	2600.	2970
1235	7520	5000	730.	1450	11400	N	1404.	2200
1328	7600	4250	763.	1600	12800	6000	271.	3880
1415	8500	4500	702.	1650	19000	14400	769.	3850
1510	7290	3000	940.	1600	31500	5000	2400.	3800
Mean	15500	10290	1040.	1650	18380	11900	1280.	2640

NOTE: All figures in mg/ℓ except sample day.
* N = no sample.

TABLE 23. SUMMARY OF TOTAL MASSES LEACHED FOR COD, BOD, ALKALINITY AND TOC, AND THEIR RATIOS, FOR MSW-ONLY LEACHATES

	Small Test Cell (10)		Large Test Cell (15)		Large/Small Ratio	
Parameter	above-soil	below-soil	above-soil	below-soil	above-soil	below-soil
COD (kg)	18.3	19.9	78.3	102.7	4.3	5.2
BOD (kg)	13.5	14.8	51.4	54.5	3.8	3.7
Alkalinity (kg)	1.8	1.7	11.9	10.9	6.6	6.4
TOC (kg)	5.1	5.1	21.3	25.0	4.1	4.9
RATIOS:						
COD/TOC	3.6	3.9	3.7	4.1	-	-
BOD/TOC	2.6	2.9	2.4	2.1	-	-
BOD/COD	0.74	0.74	0.66	0.53	-	-

mainly of organic acids and fermentation fragments which produce COD to TOC ratios in the range of 2.0 to 3.0. The additional oxygen requirement reflects levels of reduced iron, and perhaps the presence of reduced nitrogen and sulfur species. Passage of the leachate through the soil layer produces consistently higher values (by about 10%) of the ratio of COD to TOC. This increase in ratio values is apparently due to a relatively larger increase in COD than in TOC due to the soil layer (see Tables 18 and 19).

The ratio of BOD to TOC remains relatively constant throughout the experiment and is effected to some extent by the passage of leachate through the soil layer, although between-cell differences in the ratio values are relatively large and variable. The average ratio, between 2.0 and 2.5 mg oxygen required per mg of total organic carbon, is that expected from the biological oxidation of a mixture of organic acids. These results suggest that the organic composition of the leachates from each of the test cells remains relatively constant throughout the leaching period and after passage through the soil layer even though the concentrations are generally decreasing.

The third ratio, that of BOD to COD, relates to the fraction of the COD that is available to be oxidized by the microflora in the leachate. This ratio shows a small effect of the soil layer, decreasing after passage through the soil apparently caused again by the larger addition of COD by the soil-leachate interaction. In the above soil samples an average of 70% of the COD is biochemical in nature. The consistently lower BOD/COD ratio in the large test cell leachates must reflect a higher relative level of inorganic contributors to COD, i.e., a stronger leachate. The fraction of the COD which is not amenable to biological oxidation is made up of reduced inorganic ions such as ferrous iron and sulfides, or refractory organic molecules. This ratio does decline for leachates from all test cells over the experimental period indicating that the non-biologically-oxidizable portion of the COD is making up a larger fraction. That is, the inorganic or refractory organic portion of the COD decreases at a lower rate than the release of biologically oxidizable organic acids, and thus becomes a larger proportion of the overall COD.

INTERACTIONS OF THE MSW LEACHATES WITH THE SOIL LAYER

The effects of the 0.31 m soil layer beneath the MSW on the mean and highest concentrations and on the total mass/kg dry MSW of all leachate constituents analyzed are presented in Table 24, averaged for the small and large test cells. These data are derived by dividing the values for each constituent in above-soil samples from test cells 10 and 15 by the same value for the corresponding below-soil leachate samples for both test cells. Values greater than 1.0 indicate that an additional amount of the constituent was added by the passage through the soil layer; values less than one indicate that the constituent was adsorbed on, or exchanged with, soil constituents or otherwise removed from the leachate in the soil layer. A value of near 1.0 means little or no interaction between the leachate and the soil took place for that constituent.

The majority of constituents were found in slightly higher concentrations in the below-soil leachate samples than in the above-soil samples. Constituents found from 10 to 30% higher average concentration after leachate passage

TABLE 24. COMPARISON OF LEACHATE PARAMETERS ABOVE AND BELOW SOIL LAYER FOR MSW-ONLY TEST CELLS

Parameter	Mean concentration	Highest concentration	Total Mass per kg Dry MSW
Aluminum	2.75	5.65	3.19
Beryllium	N	N	N
Cadmium	2.26	3.63	6.83
Chromium	1.28	3.72	2.56
Copper	1.26	1.72	1.54
Iron	1.13	1.26	1.30
Lead	1.24	1.78	2.95
Manganese	1.22	1.66	1.31
Mercury	2.90	2.16	4.16
Nickel	1.15	1.45	1.19
Selenium	1.03	1.29	1.01
Zinc	1.26	1.70	1.51
Calcium	1.16	1.40	1.18
Magnesium	1.23	1.56	1.29
Potassium	1.12	0.96	1.05
Sodium	1.37	1.55	1.38
Arsenic	0.36	0.24	0.22
Boron	1.07	0.96	0.97
Chloride	1.13	1.35	1.14
Fluoride	1.90	1.50	3.26
Chemical ox dem	1.19	1.79	1.23
Biochem. ox dem	1.08	1.41	1.11
Tot org carbon	1.09	1.07	1.05
Alkalinity	0.97	0.77	1.00
Amine nitrogen	1.09	1.02	1.05
Total phosphate	0.22	0.27	0.20
Total vol. acids	1.07	1.60	1.25

NOTE: All values are average of test cells #10 (small) and #15 (large) and calculated as below-soil value divided by above-soil value.

through the soil layer were chromium (128%), copper (126%), iron (113%), lead (124%), manganese (122%), nickel (155%), zinc (126%), magnesium (123%), calcium (116%), potassium (112%), and chloride (113%). Selenium, boron, oxygen demand parameters, organic carbon and nitrogen levels generally had mean concentrations only 5 to 10% higher below the soil layer. These slight increases are not believed to represent significant interaction between the soil and the leachates and may be the result of an unknown experimental bias for 10-20% higher mean levels in the below-soil sample analyses.

Constituents found at significantly higher levels after the leachates have passed through the soil layer were aluminum (275% greater mean concentration), cadmium (226%), mercury (290%) fluoride (190%). Only arsenic (40 to 60% removed) and total phosphate (80 to 90% removed) were lost from the leachates in their passage through the soil layer in both test cells. The first above soil leachate sample from small test cell #10 had very high levels of cadmium, chromium, lead and zinc and may be responsible for the larger ratios seen for these constituents from this tank.

Although minor modifications in leachate composition was seen, interactions between the MSW-only leachates and the soil did not appreciably change the character or pollutant potential of the MSW leachates. Most differences seen consisted of materials being added to the leaching medium and not in their removal or in the lessening of the leachates environmental effects. The effect of the leachate on the soil appears to be much greater than the effects of the soil on the leachate. A similar effect was found to be true to an even greater extent in a similar study of leaching characteristics of flue gas cleaning wastes (28, In Press).

COMPARISON OF SMALL AND LARGE LEACHING TEST CELLS

The use of 2 sizes of test cells containing only MSW gives the opportunity to estimate the effects of cell size on the quantity and quality of landfill leachate. For these comparisons, the large test cells have twice the diameter (1.83 m versus 0.91 m), twice the depth (2.44 m versus 1.22 m), and contained eight times the compacted dry weight of MSW (an average of 2067 kg versus 262.5 kg). Since the amount of leachant added to the test cells was proportional to the top surface area of the cell (1.27 cm depth/week), the large test cells received 4 times the amount of leaching medium (deionized water at pH 6.8) than the small cells (33.4 ℓ/wk for the large versus 8.25 ℓ/wk for the small); the greater depth of the MSW in the larger cells, unfortunately results in a lower rate of leachant addition per kg dry MSW (16.2 ml/kg MSW wk for the large versus 31.5 ml/kg MSW wk for the small). Therefore, any of the three factors could be responsible for differences in the leaching characteristics of the two test cells: the total mass of the MSW compacted into the cell, the longer leaching path in the deeper cells and/or the difference in leachate production per kg dry MSW in the cells. A further complication for the MSW-only test cells is that only below-soil samples of leachate are available for comparison for one large and one small test cell making above-soil leachate comparisons possible between only one cell of each size.

As discussed above, very little difference is found between pH values of leachates from the two different cell sizes (Tables 10 and 11). However, considerable differences occurred in the amount of moisture retained ('field capacity' of the MSW) with the small cells retaining half-again more moisture per kg dry MSW than that retained in the large cells. This difference holds throughout the experimental period so that the small cells still contained 60 to 70% more moisture at the end of the experiment. No obvious cause of this difference is seen other than perhaps the greater depth of MSW in the large cells may cause them to drain more freely and thus hold smaller amounts of moisture per kg dry MSW. This higher moisture content would be expected to bring about differences in biological activity and rates of organic breakdown in the two cell sizes. Laboratory studies have shown that waste moisture content controls the rate and type of fermentative activity occurring in the waste, with higher moisture contents increasing total organic carbon levels and gas production rates (7, 11, 25).

The conductivities of the leachates from the small and large test cells were quite similar in the first year of leachate production. However, after one year conductivities of leachates from the small test cells declined more rapidly than that from the large cells. Small cell leachates were less than half the large cell leachate conductivities over the last 2 to 3 years of the study. Perhaps the higher moisture content in the wastes, and its resultant effect upon the microbial activities were responsible for the more rapid drop in conductivity values for the small cells. Or perhaps the rate of ionic materials produced (conductivity) per unit dry MSW was about the same in both cells, but the two- times higher rate of leachate addition per kg dry MSW in the small cells diluted out that leachate to a greater extent. This latter idea is supported by the fact that after about 500 days of leaching the conductivities of leachates from the small cells averages around 50% that of the leachates from the large cells (averaging 46% over the last 20 sampling periods, see Tables 12 and 13 and Figure 18).

Two general patterns of leaching appear to be present in the analysis of the metals, anions and other parameters from the two test cell sizes. One group is found in nearly equal concentrations in leachates from both cell sizes; examples are boron, calcium, copper, iron, magnesium, zinc, the oxygen demand parameters, BOD, COD and TOC, and amine nitrogen, all of which show nearly equal concentrations in leachates from the two test cell sizes (see Tables 15 and 16). The levels of these parameters appear to be limited by their solubility in the leachate or by common ion effects. They appear to be leached at concentrations independent on the amount of MSW, its depth, or the rate of leachant addition. Also these parameters have their highest levels found (Tables 17 and 18) in the leachates from the smaller test cells which average around 150% of the highest found in the large test cell leachates. Further, over the entire experiment, only about half of the total mass per kg dry MSW of these parameters were lost in the same proportion as the amount of the leachate produced (Tables 19 and 20).

For example, Figure 19 shows the rate of loss of COD from the small (#10) and large (#15) test cells which contain only MSW. Above- and below-soil leachate values are both included. The accumulated masses of COD lost are shown in Figure 20. Even though a much greater total mass of COD is lost from the larger cell, the loss per unit dry MSW for the small cell is about twice that of the large cell in direct proportion to the amount of leachate (per kg MSW) percolating through the test cell. Plotting accumulated mass of COD leached per kg dry MSW by the accumulated volume of leachate produced per kg dry MSW (figure 21) indicates that, on this basis, nearly equal amounts of COD

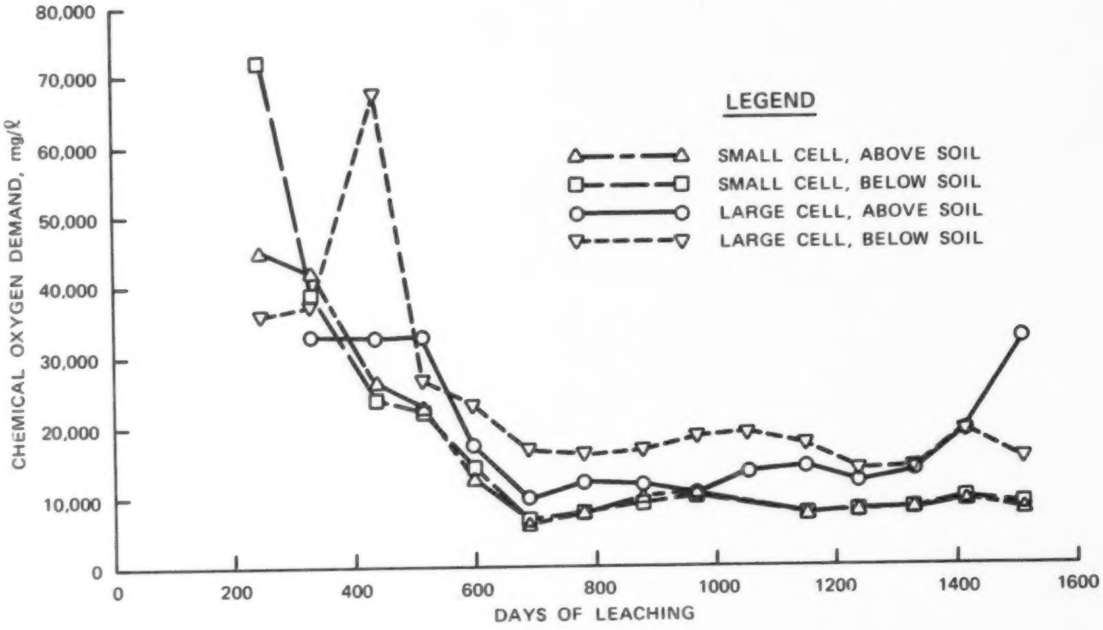

Figure 19. Plot of chemical oxygen demand concentration by days of leaching for test cells containing MSW only.

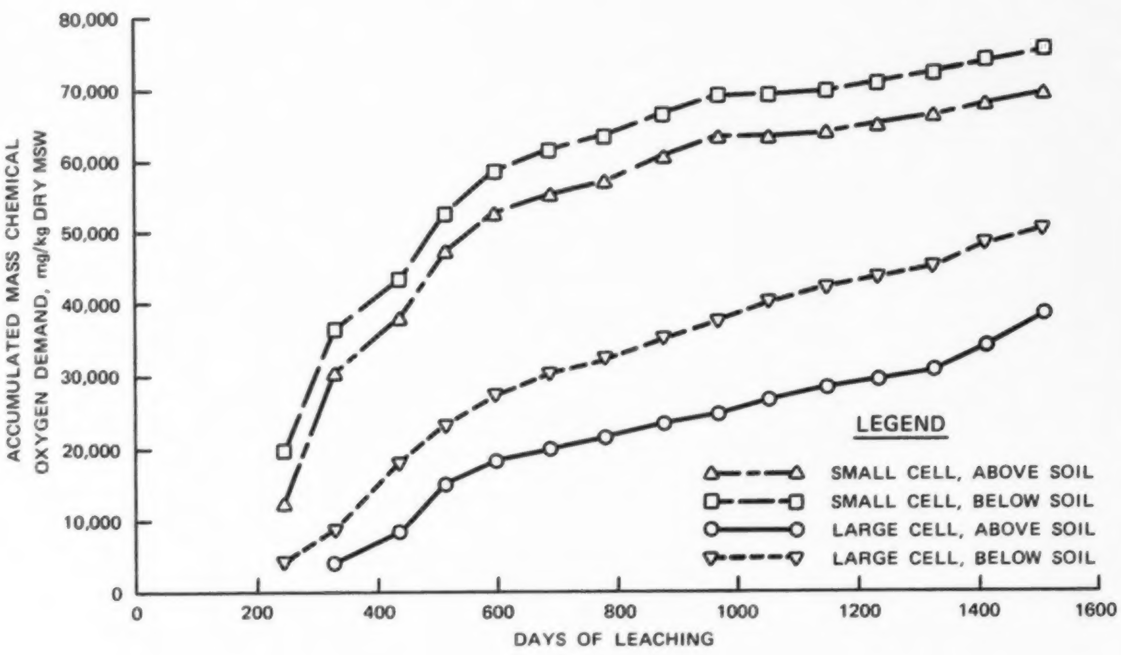

Figure 20. Plot of chemical oxygen demand for MSW-only test cell leachates.

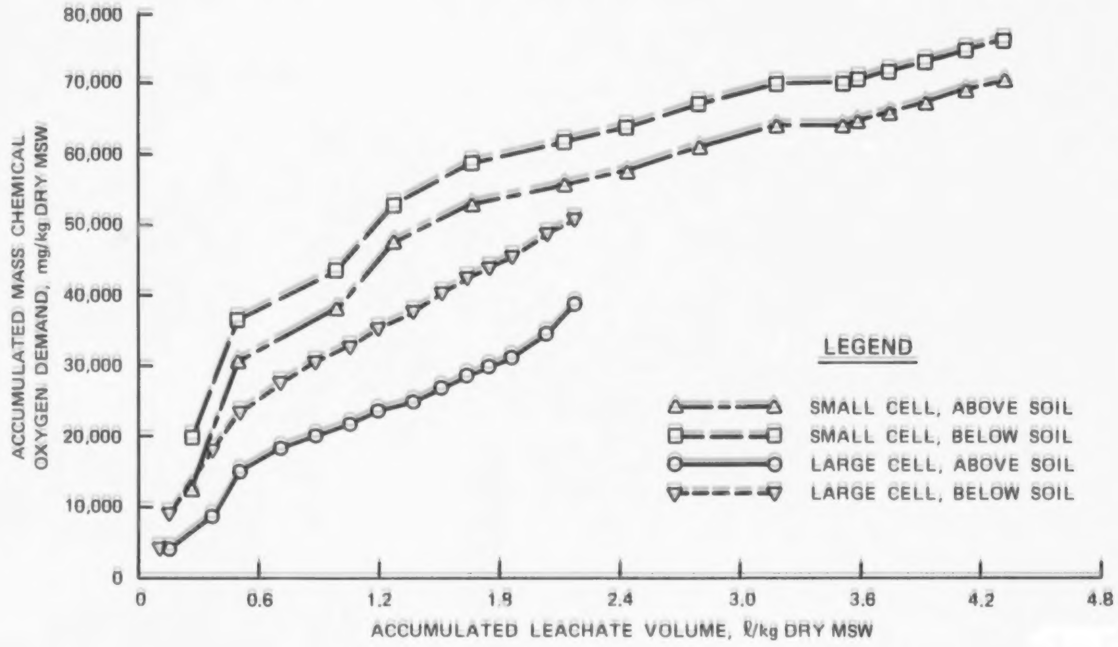

Figure 21. Plot of chemical oxygen demand by leachate volume for test cells containing only MSW.

per unit MSW dry weight are lost from both test cells. Similar results are seen for iron in Figures 22 and 23, for magnesium in Figures 24 and 25. The amount of these constituents lost from the MSW appears to be dependent primarily upon the amount of leachate produced from the test cell.

The second general class of constituent were lost more nearly in proportion to the amount of dry MSW loaded into both cell sizes rather than to the amount of leachate produced. Although a more amorphous group, the majority appear to be those of high solubility such as potassium, sodium, chloride, and TKN. Example plots as shown for chloride in Figures 26 and 27, and for sodium in Figures 28 and 29. The amount of loss of these constituents depends primarily upon the amount of waste present and to a lesser extent upon its configuration or the amount of leachate produced.

Although the data are sparse, for most purposes, the relative amount of loss of the majority of toxic materials appears to be related most closely to the amount of leachate produced rather than the amount of waste present or its configuration i.e., they tend to be solubility limited in the leachates. However for the quite soluble constituents, it appears that amounts of soluble materials can be lost in very small amounts of leachates, and the leachate concentration of these is indirectly proportional to the rate of leachate flow.

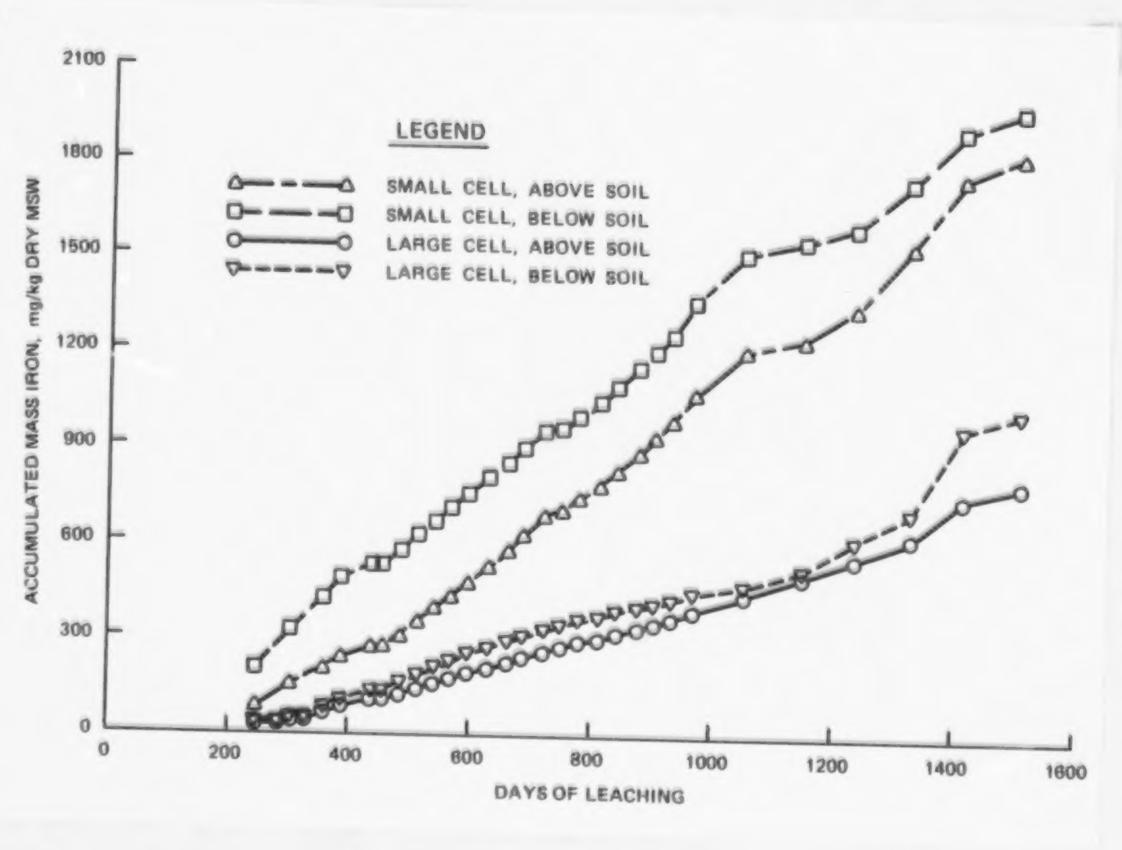

Figure 22. Iron leached by days of leaching for test cells containing only MSW.

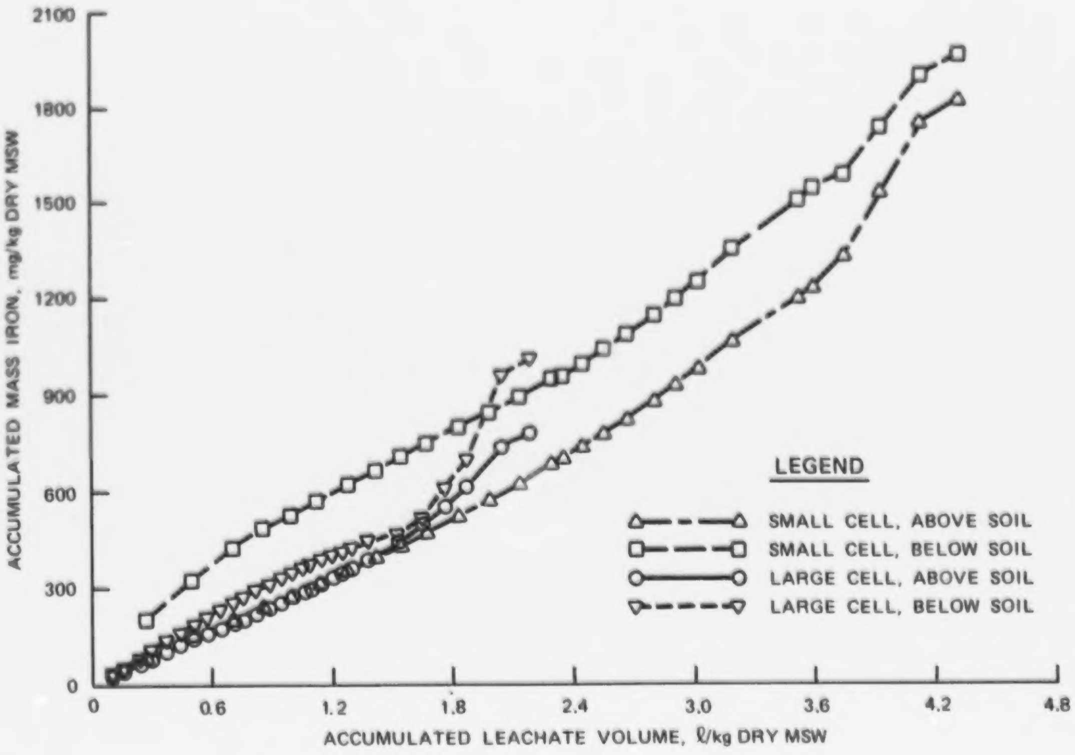

Figure 23. Iron leached by accumulated leachate volume for test cells containing only MSW.

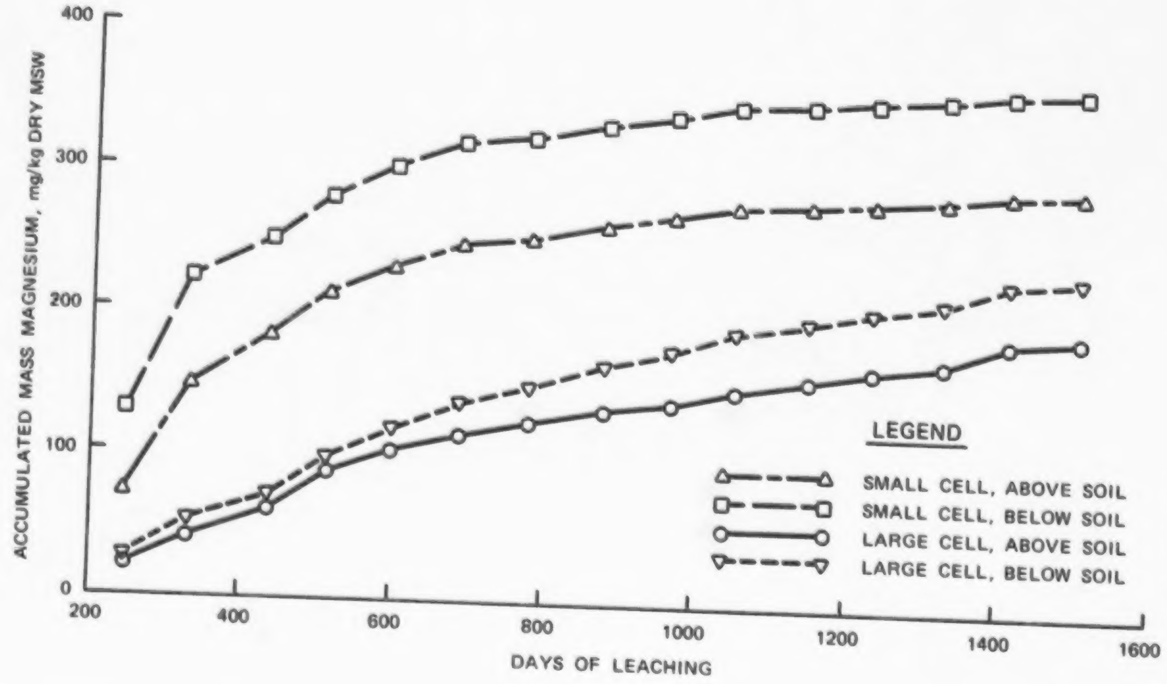

Figure 24. Plot of magnesium by days of leaching for test cells containing only MSW.

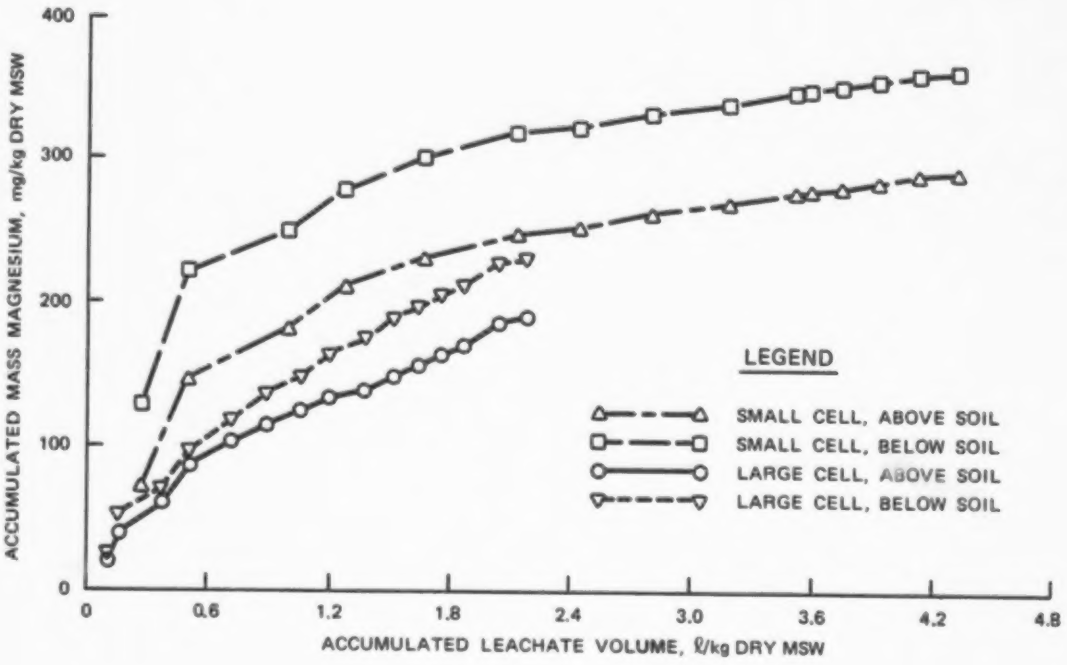

Figure 25. Plot of magnesium by volume for test cells containing MSW only.

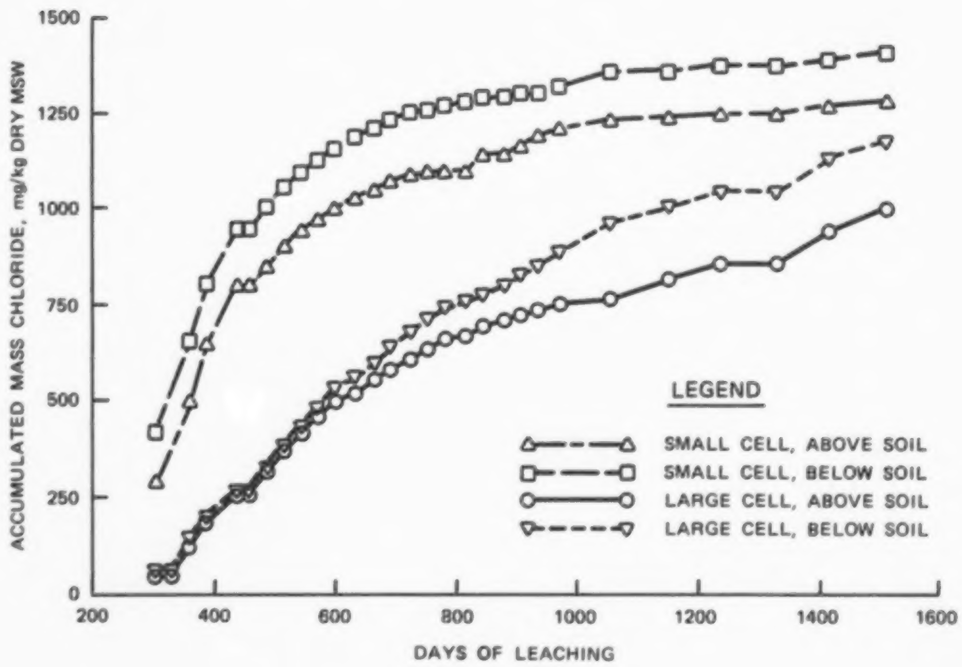

Figure 26. Plot of chloride by days of leaching for test cells containing MSW only.

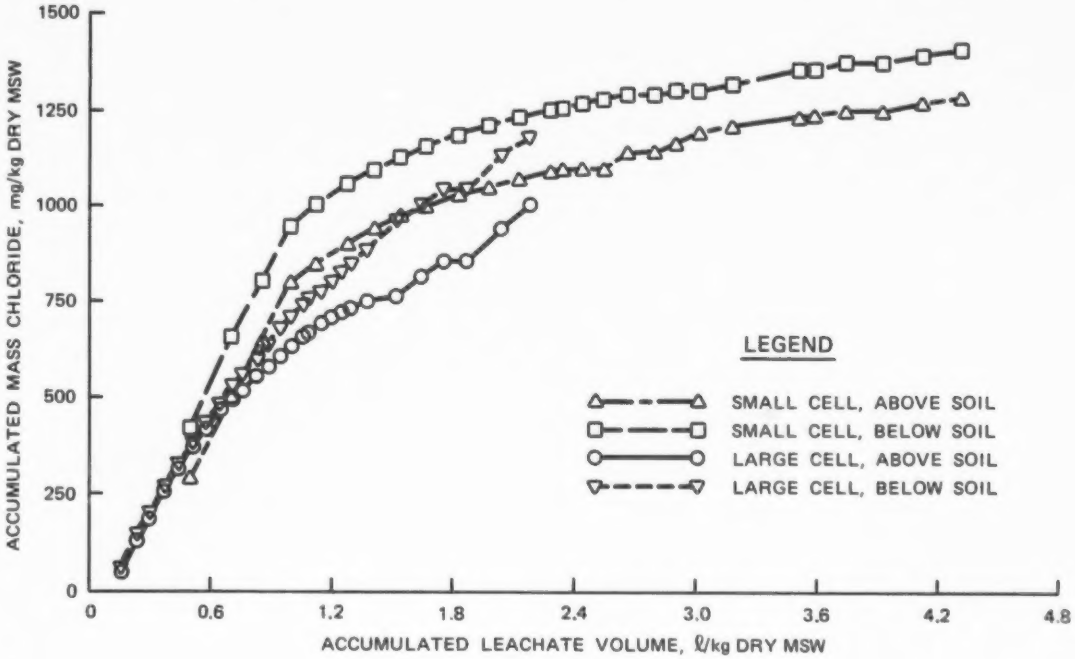

Figure 27. Plot of chloride by volume for test cells containing MSW only.

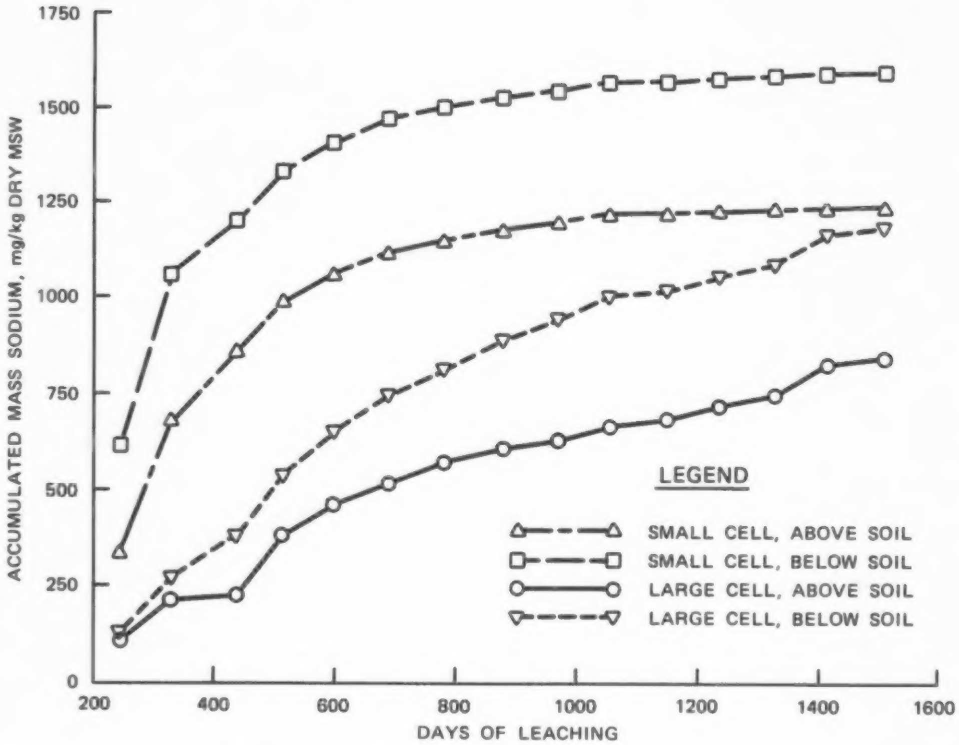

Figure 28. Plot of sodium by days of leaching for test cells containing MSW only.

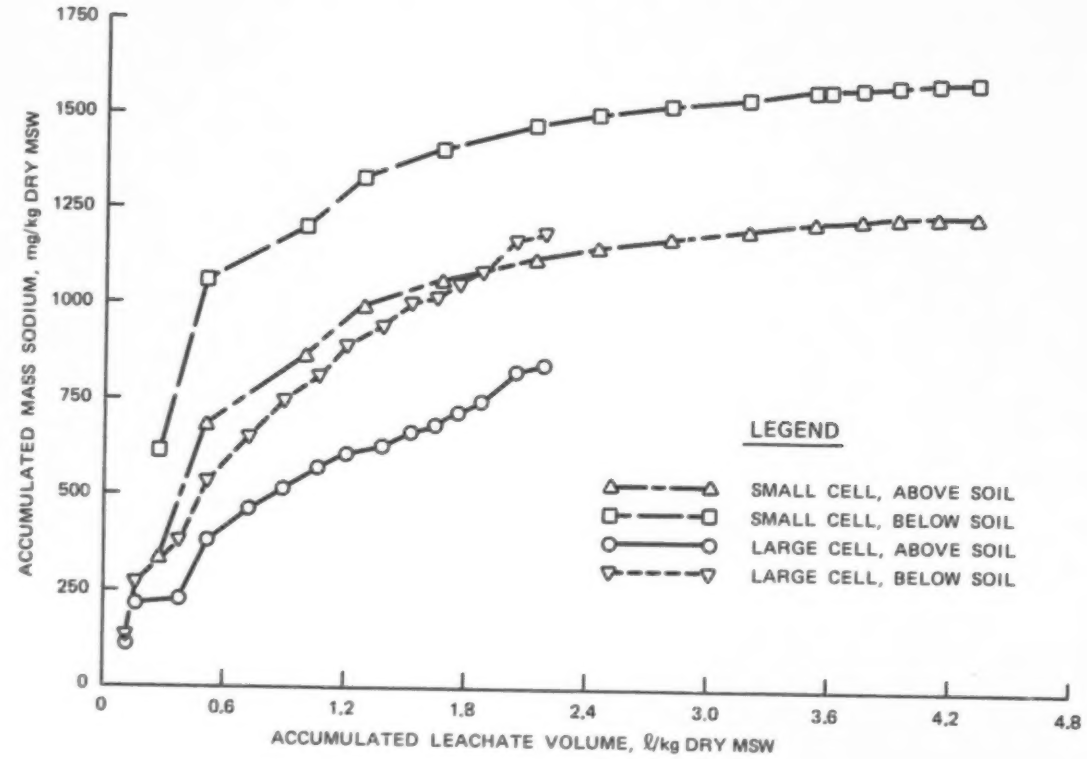

Figure 29. Plot of sodium by volume for test cells containing only MSW only.

SECTION 5
RESULTS OF LEACHING MSW CODISPOSED WITH TREATED AND UNTREATED IW

Treated and untreated samples of three industrial wastes were co-disposed with MSW in test cells identical to the MSW-only test cells described in Section 5. The wastes included were electroplating wastes (EPW), chlorine production brine (CPB) and glass etching-electronics sludge (GES). These same wastes were included in earlier studies from this laboratory where they were identified as sludge numbers, 200, 800, and 900 respectively (22, 23). The two waste treatment methods included were Process A which added cement and a patented ingredient to the IW and Process B which used lime and flyash as treatment reagents. The process designations do not refer to any of the treatment systems used in previous studies from this laboratory.

Two layers of the treated or untreated IWs were included in the MSW loaded into each of 9 of the large test cells. These cells were leached with deionized water (pH 5.5) for 1510 days in a manor identical to the MSW-only test cells. Leachate samples were collected from above and below a 0.31 m layer of sandy soil. Analyses of leachate parameters from these test cells are compared with those from test cells containing MSW only.

Leachate characteristics and constituent concentrations are displayed in the same way as the MSW-only values for ease of comparison between the different IWs and treatments. The three statistics shown are the average concentration or value for the parameter in all leachate samples, the highest concentration or value found for the parameter in any leachate sample, and the total amount of the constituent leached over the 1510 day study calculated per kg of dry MSW loaded into the test cell. In some tables, ratios between the amount or value of the parameter is compared with the corresponding value from the large, MSW-only test cells; value for the ratio greater than 1 indicating increased levels in the leachates from the IW containing cells and less than 1, lower levels in the IW containing test cell's leachates. Corresponding values for the large MSW-only test cells are also shown in some tables for ease of comparison.

ELECTROPLATING WASTE (EPW) CODISPOSAL

The electroplating waste was a bright-green, clay-like material with greater than 0.5% dry weight of aluminum, calcium, chromium, copper, magnesium, iron, sodium, zinc, chloride, sulfate and silicon, and appreciable (greater than 300 mg/kg) of boron, beryllium, cadmium, lead, manganese, nickel, potassium and zinc. Complete bulk analyses of the EPW are given in Table 2 and Appendix A. Test cell 19 contained 2035 kg (dry wt) of MSW and 2200 kg wet wt (704 kg dry solids) of untreated EPW in two layers as described under test cell loading (page 33). Test cell 14 received 2038 kg (dry wt) MSW and 1951 kg of EPW solidified by Process A (312 kg of dry EPW solids). Test cell 11 contained 2038 kg (dry wt) MSW and 2317 kg of EPW treated by Process B (359 kg of dry EPW solids).

Moisture Retention and Leachate Volumes

As for the MSW-only test cells, 33.4 ℓ of deionized water were added each week throughout the experiment. This amount is equivalent to 1.27 cm infiltration/wk (66 cm/yr) or 15.9 ml/kg MSW wk (0.83 ℓ/kg dry MSW year). The volume of leachates collected and retained in the test cells containing EPW are shown in Table 25. A total of 2.13 ℓ of leachate/kg dry MSW was produced over the 1510 day study in test cell containing untreated EPW (cell 19), and 2.20 ℓ and 2.10 ℓ of leachate/kg dry MSW for the test cells containing treated EPW (test cells 14 and 11).

The amount and pattern of moisture retention in the test cells is quite similar to that for the large MSW-only test cells, averaging between 500 and 600 ml of moisture per kg dry MSW in the first 6 months of leachate collection. The amount of moisture retained slowly increased over the leaching period so that by the end of the study between 1.3 and 1.4 ℓ had been retained per kg MSW, again quite consistent with the large, MSW-only test cells. The volumes of leachate produced and moisture retained in the test cells do not appear to be affected by the presence of treated or untreated EPW. Very similar patterns and amounts are seen for both.

Untreated EPW-MSW Leachate Characteristics

The average values of all leachate parameters for the test cells containing treated and untreated EPW are shown in Table 26 for above-soil samples and in Table 27 for the below-soil samples. The corresponding highest values in any single leachate sample are given in Tables 28 and 29; and the total mass leached/kg dry MSW in Tables 30 and 31.

The presence of the untreated EPW in the MSW brings about a more basic leachate with a pH averaging one full unit higher. The presence of the EPW also appears to have a pronounced effect upon the biological activities in the MSW by causing a dramatic decrease in the biochemical oxygen demand (BOD) and total organic carbon (TOC) to about half that in the MSW-only leachates. Total Kjeldahl nitrogen and phosphate levels are also considerably lower in the EPW-MSW leachates.

The BOD/COD ratios of young MSW leachates are usually over 0.60 and the COD/TOC ratio over 2.8 (25); such typical values were seen for the MSW-only leachates. The much lower BOD/COD ratio for the untreated EPW-MSW leachate (0.40) (as well as higher COD/TOC ratios and more basic pH) indicate that the majority of the COD in the EPW-MSW leachates is not made up of the volatile organic acids which are typical of MSW-only leachates. The average levels of both the COD and BOD are 4000 to 5000 mg/l lower (and total masses leached, 12,000 to 14,000 mg/kg dry MSW less) than both the MSW-only and treated EPW-MSW leachates. This decrease must account for the missing portion of the biologically produced, volatile organic-acid fraction.

Ratios of the levels of constituents found in the EPW-MSW leachates to the levels in MSW-only leachates are also shown in the Tables. Of the cations present at levels greater than 0.5% (5000 mg/kg) in the EPW dry solids--aluminum, calcium, chromium, copper, iron, magnesium, sodium, and zinc--average leachate concentrations over the entire 1510 days in the untreated EPW-MSW leachates for these constituents are consistently from 190% to 210% of their levels in the MSW-only leachates for all but iron and zinc. The total masses of these constituents leached and their highest leachate concentrations follow very similar patterns to their average concentrations.

TABLE 25. VOLUMES OF LEACHATES COLLECTED AND RETAINED FROM TEST CELLS CONTAINING EPW

	Volume Produced			Volume Retained		
Sample Day	Untr. (19)	A (14)	B (11)	Untr. (19)	A (14)	B (11)
247	153.0	89.0	38.0	0.50	0.53	0.56
282	0.0	0.0	0.0	0.59	0.62	0.64
303	114.3	114.0	86.7	0.58	0.61	0.65
331	0.0	179.0	0.0	0.64	0.59	0.72
359	201.7	136.3	207.4	0.61	0.59	0.68
388	134.5	123.9	134.9	0.61	0.59	0.68
437	158.2	155.9	145.3	0.65	0.63	0.73
458	0.0	0.0	0.0	0.70	0.68	0.78
486	127.2	158.2	138.6	0.70	0.67	0.77
514	115.5	113.6	105.2	0.71	0.68	0.79
542	106.8	113.6	111.7	0.72	0.69	0.80
570	118.5	126.1	111.3	0.73	0.69	0.81
598	111.7	153.7	128.7	0.74	0.68	0.81
633	135.9	137.4	107.1	0.76	0.70	0.84
664	137.8	155.2	145.3	0.76	0.69	0.84
689	127.1	147.1	136.2	0.76	0.68	0.83
724	87.1	158.0	94.5	0.80	0.68	0.87
752	109.4	108.3	53.4	0.81	0.70	0.91
780	110.9	110.0	85.5	0.82	0.71	0.93
815	92.7	104.5	115.1	0.86	0.74	0.96
843	99.2	110.5	64.0	0.87	0.75	0.99
878	107.1	92.7	87.4	0.90	0.79	1.03
906	51.5	127.9	110.1	0.94	0.79	1.04
934	61.7	115.1	94.6	0.98	0.80	1.06
969	0.0	0.0	0.0	1.06	0.88	1.14
1053	320.6	361.2	396.7	1.19	1.02	1.25
1150	280.4	209.3	251.5	1.10	0.90	1.15
1235	348.2	329.7	304.7	1.22	1.06	1.30
1328	287.1	97.7	225.0	1.30	1.23	1.41
1415	283.1	292.2	447.4	1.36	1.29	1.39
1510	348.8	361.1	337.7	1.41	1.34	1.45
Total	4330	4481	4264	-	-	-

NOTE: Volume produced in l.
Volume retained in l/kg dry MSW.

TABLE 26. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR ABOVE-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW Only	MSW + EPW			MSW+EPW/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.459	0.889	0.424	N*	1.93	0.92	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0039	0.0100	0.0039	N	2.56	1.00	N
Chromium	0.128	0.238	0.121	N	1.86	0.94	N
Copper	0.010	0.022	0.015	N	2.15	1.42	N
Iron	323.	210.	331.	N	0.65	1.03	N
Lead	0.036	0.013	0.046	N	0.35	1.26	N
Manganese	10.0	5.10	9.13	N	0.51	0.91	N
Mercury	0.0010	0.0013	0.0013	N	1.29	1.24	N
Nickel	0.229	0.285	0.324	N	1.24	1.41	N
Selenium	0.104	0.069	0.196	N	0.66	1.88	N
Zinc	7.90	3.29	4.80	N	0.41	0.60	N
Calcium	520.	685.	781.	N	1.32	1.50	N
Magnesium	86.9	187.1	99.8	N	2.15	1.15	N
Potassium	326.	330.	435.	N	1.01	1.34	N
Sodium	377.	820.	568.	N	2.17	1.50	N
Arsenic	0.085	0.126	0.053	N	1.47	0.62	N
Boron	2.38	9.80	3.82	N	4.10	1.60	N
Chloride	567.	668.	706.	N	1.18	1.25	N
Fluoride	0.156	0.672	0.288	N	4.29	1.84	N
COD	18385.	14281.	20040.	N	0.78	1.09	N
BOD	11922.	5703.	12169.	N	0.48	1.02	N
BOD/COD	0.65	0.40	0.61	N	-	-	-
COD/TOC	3.06	3.39	2.64	N	-	-	-
TOC	6004.	4208.	7577.	N	0.70	1.26	N
Alkalinity	2642.	3810.	2707.	N	1.44	1.02	N
pH	5.31	6.31	5.31	N	1.19	1.00	N
Vol. Acids	1281.	933.	1931.	N	0.73	1.51	N
TK Nitrogen	542.	421.	517.	N	0.78	0.95	N
Phosphate	22.6	4.75	16.5	N	0.21	0.73	N
Volume (l/mo)	143.2	139.	144.	N	0.98	1.01	N

* N = All values below detection limits or no data.

TABLE 27. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW Only	MSW + EPW			MSW+EPW/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	1.706	0.687	1.194	0.560	0.40	0.70	0.32
Beryllium	0.014	0.017	0.018	0.015	1.17	1.24	1.03
Cadmium	0.0041	0.0051	0.0037	0.0091	1.24	0.91	2.24
Chromium	0.100	0.105	0.213	0.095	1.04	2.12	0.94
Copper	0.012	0.029	0.011	0.009	2.44	0.93	0.74
Iron	396.25	404.90	400.56	357.52	1.02	1.01	0.90
Lead	0.016	0.013	0.018	0.016	0.81	1.14	1.06
Manganese	11.9	7.30	11.6	14.4	0.61	0.97	1.21
Mercury	0.0029	0.0011	0.0022	0.0022	0.37	0.77	0.76
Nickel	0.236	0.327	0.397	0.378	1.38	1.67	1.59
Selenium	0.071	0.180	0.142	0.124	2.54	2.00	1.75
Zinc	8.24	0.989	6.10	13.8	0.12	0.74	1.67
Calcium	618.	734.	883.	833.	1.19	1.43	1.35
Magnesium	105.	228.	128.	132.	2.16	1.22	1.25
Potassium	395.	378.	532.	525.	0.96	1.34	1.33
Sodium	535.	981.	719.	724.	1.83	1.34	1.35
Arsenic	0.045	0.145	0.045	0.042	3.21	0.99	0.93
Boron	2.82	12.0	5.47	6.25	4.28	1.93	2.21
Chloride	672.	763.	824.	804.	1.14	1.23	1.20
Fluoride	0.347	0.680	0.306	0.300	1.96	0.88	0.86
COD	23216.	15232.	24915.	23956.	0.66	1.07	1.03
BOD	12183.	9472.	15725.	13410.	0.78	1.29	1.10
BOD/COD	0.52	0.62	0.63	0.56	-	-	-
COD/TOC	3.25	2.75	2.87	2.97	-	-	-
TOC	7145.	5544.	8675.	8060.	0.78	1.21	1.13
Alkalinity	2555.	4443.	3531.	2956.	1.74	1.38	1.16
pH	5.34	6.23	5.37	5.24	1.17	1.01	0.98
Vol. Acids	1709.	2407.	3015.	2788.	1.41	1.76	1.63
TK Nitrogen	633.	528.	709.	615.	0.83	1.12	0.97
Phosphate	3.14	2.78	4.27	9.12	0.89	1.36	2.91
Volume (l/mo)	143.	139.	144.	137.	0.98	1.01	0.96

TABLE 28. HIGHEST CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR ABOVE-SOIL SAMPLES

	Concentration (mg/1)				Ratios		
	MSW Only	MSW + EPW			MSW+EPW/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	2.00	2.90	1.88	N*	1.45	0.94	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0219	0.0900	0.0325	N	4.10	1.48	N
Chromium	0.338	0.660	0.328	N	1.95	0.97	N
Copper	0.030	0.058	0.033	N	1.93	1.10	N
Iron	713.	515.	710.	N	0.72	1.00	N
Lead	0.158	0.035	0.193	N	0.22	1.22	N
Manganese	18.6	16.1	18.7	N	0.86	1.00	N
Mercury	0.0023	0.0038	0.0025	N	1.65	1.08	N
Nickel	0.483	0.573	0.685	N	1.18	1.41	N
Selenium	0.160	0.078	0.243	N	0.48	1.51	N
Zinc	21.7	14.6	20.4	N	0.67	0.94	N
Calcium	1117.	1552.	1180.	N	1.39	1.06	N
Magnesium	177.	330.	238.	N	1.86	1.34	N
Potassium	N	N	N	N	N	N	N
Sodium	942.	1405.	1332.	N	1.49	1.41	N
Arsenic	0.280	0.155	0.150	N	0.55	0.53	N
Boron	8.09	21.3	14.1	N	2.63	1.74	N
Chloride	1063.	1480.	1719.	N	1.39	1.62	N
Fluoride	0.349	1.67	1.25	N	4.79	3.58	N
COD	32600.	36650.	44800.	N	1.12	1.37	N
BOD	25000.	23500.	31000.	N	0.94	1.24	N
TOC	12000.	12600.	13200.	N	1.05	1.10	N
Alkalinity	8000.	5860.	4830.	N	0.73	0.60	N
pH	6.20	7.40	6.00	N	-	-	-
Vol. Acids	3715.	5520.	4850.	N	-	-	-
TK Nitrogen	881.	711.	1550.	N	0.81	1.76	N
Phosphate	31.40	10.70	28.00	N	0.34	0.89	N

* N = All values below detection or no data.

TABLE 29. HIGHEST CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l-)				Ratios		
	MSW Only	MSW + EPW			MSW+EPW/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	14.9	2.90	8.45	4.20	0.19	0.56	0.28
Beryllium	0.017	0.023	0.018	0.015	1.31	1.02	0.85
Cadmium	0.0185	0.0250	0.0360	0.1087	1.35	1.94	5.87
Chromium	0.361	0.317	2.750	0.900	0.88	7.61	2.49
Copper	0.040	0.087	0.030	0.085	2.17	0.75	2.13
Iron	1470.	722.	733.	613.	0.49	0.50	0.42
Lead	0.052	0.027	0.065	0.127	0.52	1.25	2.44
Manganese	23.1	17.4	29.7	26.2	0.75	1.28	1.13
Mercury	0.0055	0.0015	0.0098	0.0075	0.27	1.78	1.36
Nickel	0.468	1.200	1.210	0.730	2.56	2.58	1.56
Selenium	0.125	0.198	0.278	0.145	1.58	2.22	1.16
Zinc	19.0	3.10	25.8	47.5	0.16	1.35	2.50
Calcium	1372.	1470.	1727.	1230.	1.07	1.26	0.90
Magnesium	222.	540.	310.	252.	2.43	1.39	1.14
Potassium	N	N	N	N	N	N	N
Sodium	1142.	2180.	1895.	1295.	1.91	1.66	1.13
Arsenic	0.140	0.400	0.090	0.115	2.85	0.64	0.82
Boron	8.74	39.2	22.2	15.0	4.48	2.54	1.71
Chloride	1322.	1445.	1839.	1552.	1.09	1.39	1.17
Fluoride	0.775	2.45	0.680	0.737	3.16	0.87	0.95
COD	66800.	36160.	57300.	40600.	0.54	0.86	0.61
BOD	32000.	44000.	42000.	27000.	1.38	1.31	0.84
TOC	13500.	10900.	15200.	13000.	0.81	1.13	0.96
Alkalinity	5200.	6680.	5800.	5210.	1.28	1.12	1.00
pH	6.00	7.50	5.90	5.80	1.25	0.98	0.97
Vol. Acids	9740.	7820.	11082.	7670.	0.80	1.14	0.79
TK Nitrogen	966.	1750.	2930.	1920.	1.81	3.03	1.99
Phosphate	4.90	6.90	17.10	18.20	1.41	3.49	3.71

TABLE 30. TOTAL MASS PER KG DRY MSW AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR ABOVE SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW Only	MSW + EPW			MSW+EPW/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.915	1.50	1.00	N*	1.64	1.09	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0072	0.0165	0.0084	N	2.29	1.16	N
Chromium	0.242	0.385	0.237	N	1.58	0.97	N
Copper	0.015	0.035	0.022	N	2.32	1.43	N
Iron	779.	328.	752.	N	0.42	0.97	N
Lead	0.054	0.015	0.048	N	0.28	0.90	N
Manganese	21.8	11.2	20.7	N	0.51	0.95	N
Mercury	0.0005	0.0005	0.0005	N	0.92	0.97	N
Nickel	0.505	0.606	0.760	N	1.20	1.50	N
Selenium	0.057	0.032	0.072	N	0.56	1.26	N
Zinc	14.7	3.52	9.17	N	0.23	0.62	N
Calcium	1117.	1496.	1721.	N	1.34	1.54	N
Magnesium	189.	391.	228.	N	2.07	1.21	N
Potassium	723.	687.	1019.	N	0.95	1.41	N
Sodium	838.	1693.	1318.	N	2.02	1.57	N
Arsenic	0.102	0.045	0.061	N	0.43	0.59	N
Boron	4.94	20.3	8.90	N	4.12	1.79	N
Chloride	995.	1175.	1310.	N	1.18	1.32	N
Fluoride	0.191	0.927	0.308	N	4.85	1.61	N
COD	38405.	24977.	45965.	N	0.65	1.20	N
BOD	25203.	12573.	29286.	N	0.50	1.16	N
BOD/COD	0.66	0.50	0.64	N	-	-	-
COD/TOC	3.67	4.60	3.60	N	-	-	-
TOC	10471.	5427.	12761.	N	0.52	1.22	N
Alkalinity	5849.	7543.	5645.	N	1.29	0.97	N
Vol. Acids	2387.	2003.	4125.	N	0.84	1.73	N
TK Nitrogen	1191.	830.	1153.	N	0.70	0.97	N
Phosphate	50.1	9.23	35.5	N	0.18	0.71	N

* N = All values below detection limits or no data.

TABLE 31. TOTAL MASS PER KG DRY MSW AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED ELECTROPLATING WASTE (200) FOR BELOW-SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW	MSW + EPW			MSW+EPW/MSW-Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	3.03	1.02	1.97	0.92	0.33	0.65	0.30
Beryllium	0.007	0.013	0.001	0.002	1.87	0.11	0.32
Cadmium	0.0073	0.0071	0.0059	0.0111	0.98	0.81	1.52
Chromium	0.196	0.183	0.327	0.143	0.93	1.67	0.73
Copper	0.018	0.045	0.015	0.014	2.57	0.87	0.79
Iron	1007.	673.	908.	799.	0.67	0.90	0.79
Lead	0.022	0.017	0.028	0.047	0.77	1.29	2.14
Manganese	25.8	14.6	25.4	29.1	0.56	0.98	1.12
Mercury	0.0018	0.0006	0.0117	0.0008	0.31	6.60	0.47
Nickel	0.522	0.634	0.845	0.748	1.21	1.62	1.43
Selenium	0.031	0.054	0.062	0.036	1.75	2.01	1.18
Zinc	15.1	0.551	10.6	21.1	0.03	0.70	1.39
Calcium	1338.	1627.	1900.	1702.	1.22	1.42	1.27
Magnesium	230.	471.	281.	268.	2.05	1.22	1.16
Potassium	876.	785.	1174.	1050.	0.90	1.34	1.20
Sodium	1178.	1997.	1577.	1478.	1.70	1.34	1.26
Arsenic	0.046	0.119	0.044	0.058	2.59	0.96	1.26
Boron	5.83	24.06	10.96	12.07	4.12	1.87	2.07
Chloride	1175.	1294.	1530.	1447.	1.10	1.28	1.23
Fluoride	0.471	0.905	0.396	0.317	1.92	0.83	0.67
COD	50151.	30942.	54699.	48803.	0.62	1.09	0.97
BOD	26581.	18771.	34467.	25693.	0.71	1.30	0.97
BOD/COD	0.53	0.61	0.63	0.53	1.14	1.19	0.99
COD/TOC	4.12	4.05	3.71	3.93	0.98	0.90	0.95
TOC	12164.	7642.	14763.	12420.	0.63	1.21	1.02
Alkalinity	5328.	8615.	7581.	6115.	1.62	1.42	1.15
Vol. Acids	3931.	4898.	5465.	5365.	1.25	1.39	1.36
TK Nitrogen	1401.	954.	1326.	1042.	0.68	0.95	0.74
Phosphate	5.45	4.20	7.32	15.68	0.77	1.34	2.88

Two plots comparing the accumulated mass of calcium found in the MSW-only and EPW-MSW leachates for above and below soil leachate samples are shown in Figures 30 and 31. First, notice the similarity of leaching patterns for leaching rates above and below the soil layer; this is important because no above soil samples are available for the test cell containing EPW treated by process B. In general, the amount of calcium leached over the first year of leaching (up to about 0.4 l/kg dry MSW) is very similar in all test cells, the amount lost from the MSW-only test cell being smaller only from this time on. Second, note that the test cell containing untreated EPW lost calcium at a higher rate early in the leaching period, but this rate abruptly diminished after about 800 or 900 days of leaching (after about 1 ℓ/kg dry MSW of leachate had been produced). This break in consistent loss rate is also seen at this time for other constituents as discussed below.

Iron and zinc have lower average concentrations and total masses leached in the untreated EPW-MSW leachates (65% and 41% of the average concentrations in MSW-only leachates, respectively) perhaps due to the lower microbial activity and the leachate's more basic pH values. The accumulated amount of iron in the leachates from all cells containing treated and untreated EPW are shown for above-soil samples in Figure 32 and for below-soil samples in Figure 33. In both cases the amount of iron released from the untreated EPW waste is quite similar (above the soil layer) or higher (in below soil samples) until about 1 ℓ of leachate has been produced per kg of MSW in the test cell at which time the rate of iron leaching drops dramatically. The drop in rate of iron losses in the above soil leachate samples occurs at about day 800, and below soil samples at about day 900.

Similar abrupt increases in leaching rates occur at about this same time in the amounts of copper and chromium being leached (see Figures 34 and 35). And again, at the same time, decreases in leaching rates are seen in manganese, COD and BOD, total organic carbon, and total volatile acids. Further, at this time, the pH of the leachate increase from averaging around 6.0 to around 7.0 where it remained throughout the remainder of the study. Evidently the full effects of the untreated EPW on the MSW leachates were not fully expressed in this test cell until after 2 1/2 to 3 years of leaching at which time chemical and biological conditions in the test cell apparently changed dramatically.

Chloride, the major anion found in the EPW (22% of dry EPW solids), has both an average concentration and a total mass leached in the EPW-MSW leachates of 118% of its MSW-only level. Plots of accumulated amounts of chloride leached in above and below soil samples are shown in Figures 36 and 37. In all cases, chloride is lost at consistently higher amounts from the test cells containing EPW. In contrast to the constituents listed above, no changes in the rate of chloride loss, other than a gradual lessening, are seen at around day 800. For other anions, boron (Figure 38) is found at 410% and fluoride at over 430% of the MSW-only leachates, again by both average concentration and total mass leached.

Of the minor EPW constituents, those present at 1000 mg/kg dry EPW solids or less, cadmium (180%), mercury (129%), nickel (120%), and potassium (100%) were lost at the same or moderately higher concentrations from the EPW-MSW test cells. Lead (35%), manganese (51%) and selenium (66%) were lost in lower average concentrations and total masses.

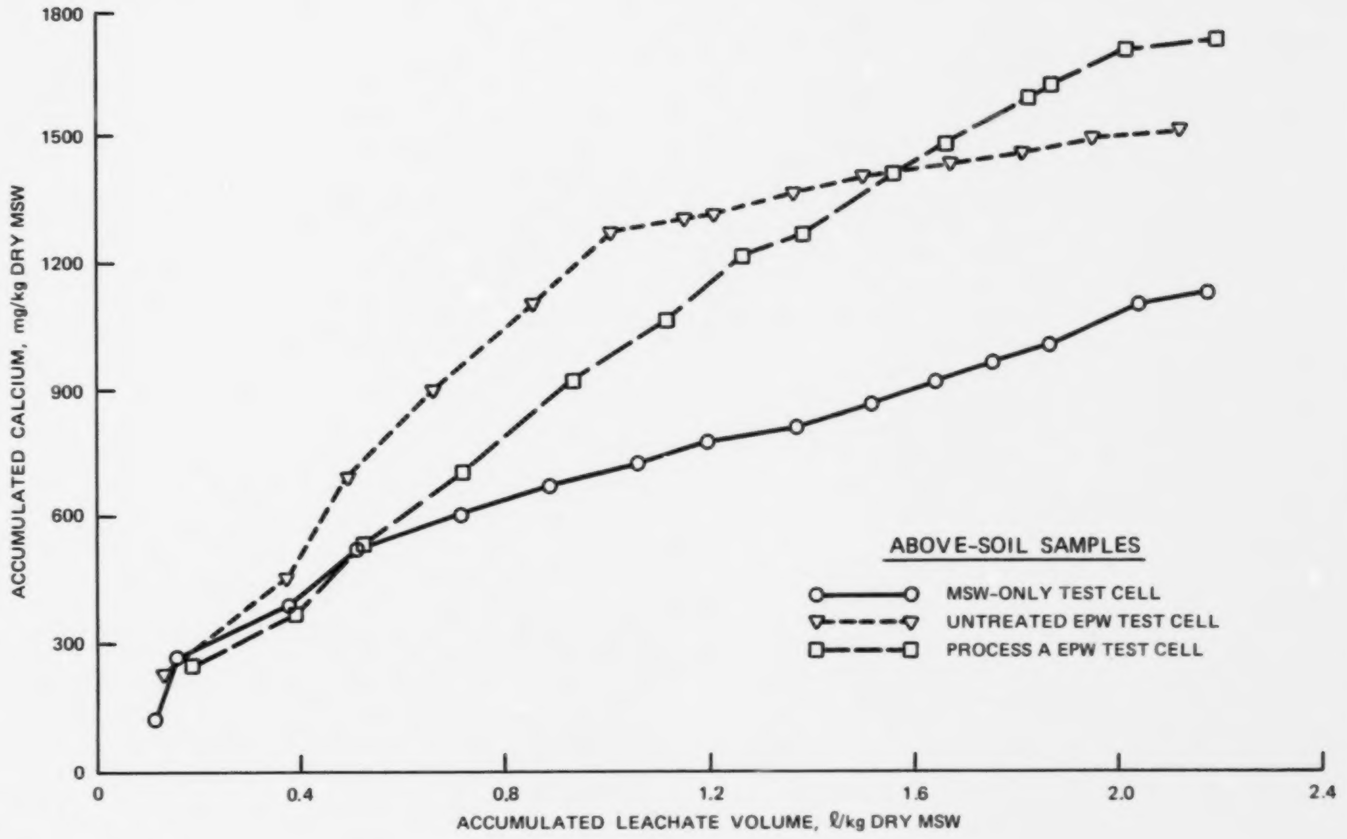

Figure 30. Plot of calcium by accumulated volume for above-soil leachates.

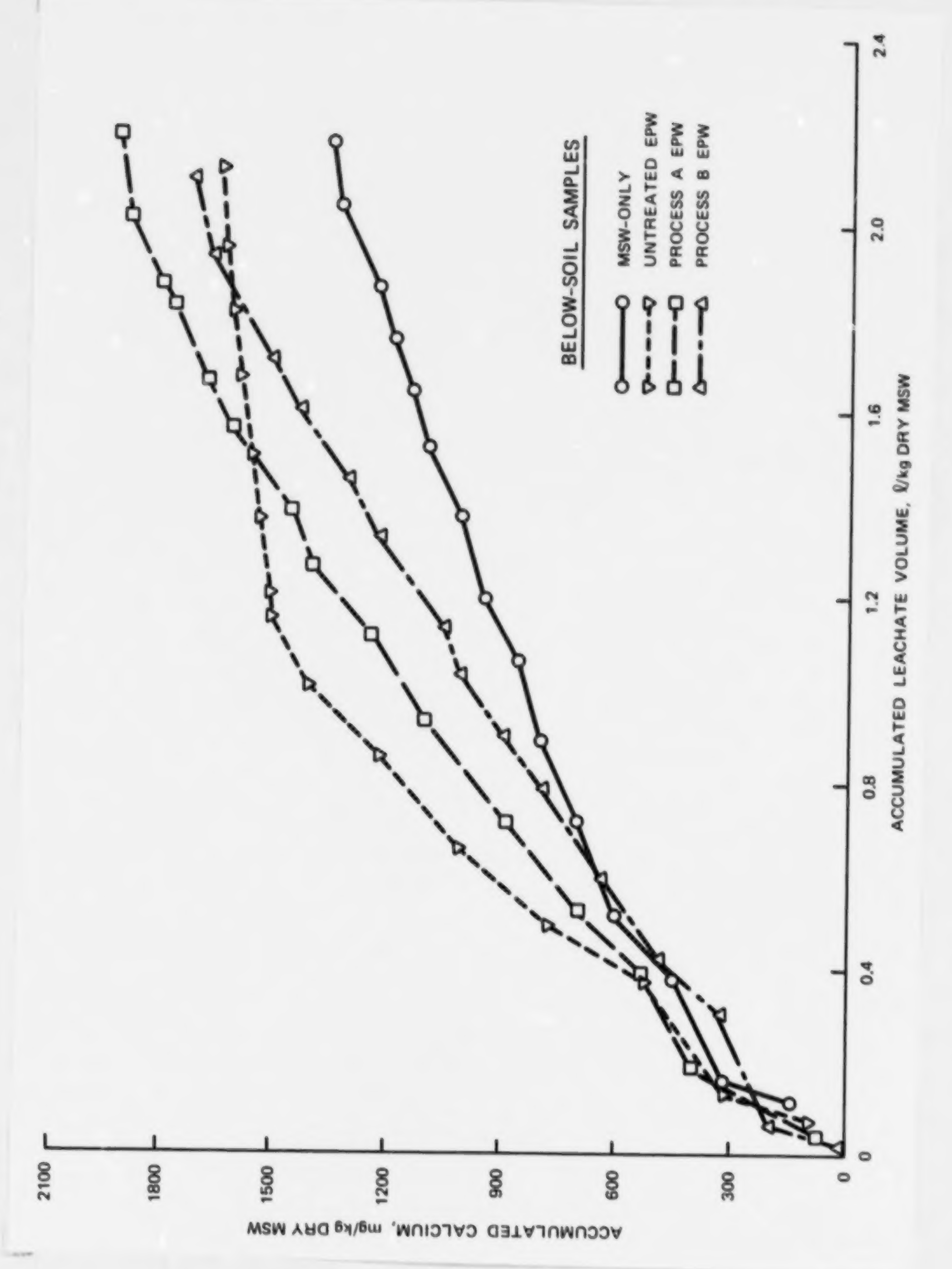

Figure 31. Plot of calcium by volume for below-soil leachates.

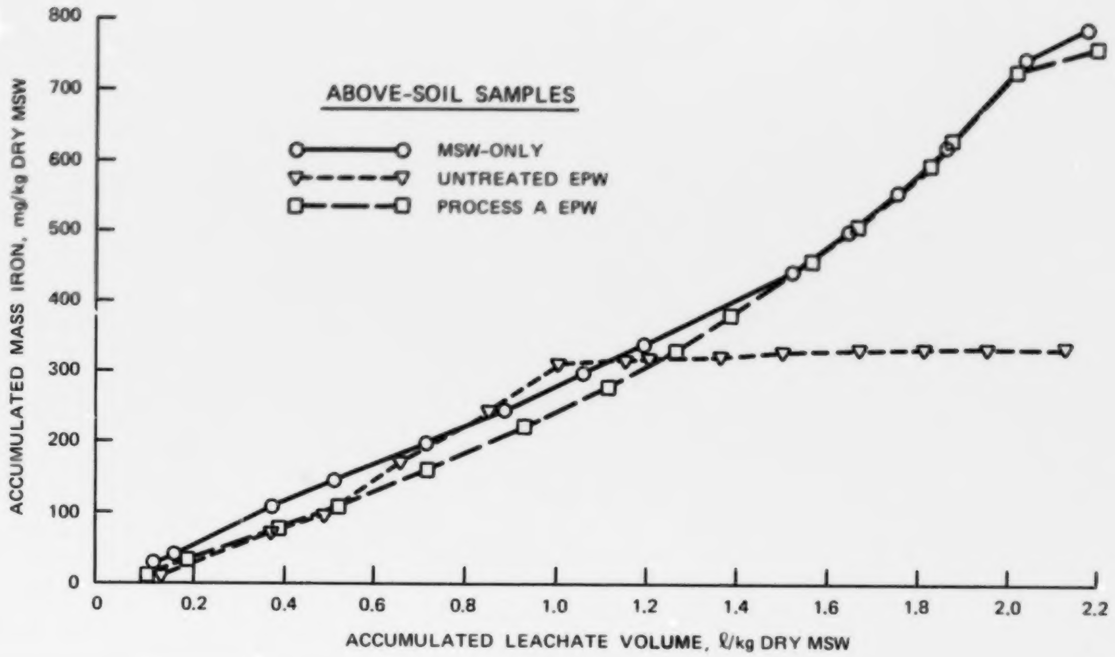

Figure 32. Plot of iron by volume for above-soil, EPW leachates.

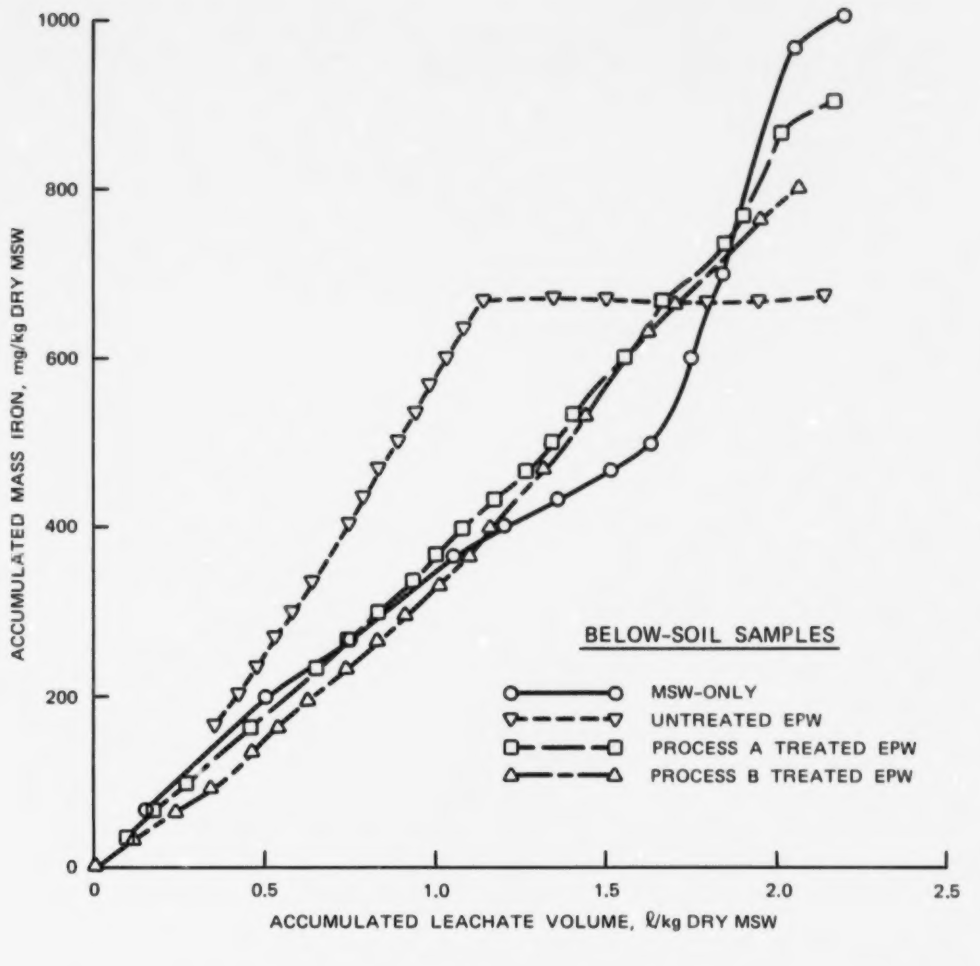

Figure 33. Plot of accumulated mass of iron by accumulated leachate volume for below-soil leachate samples.

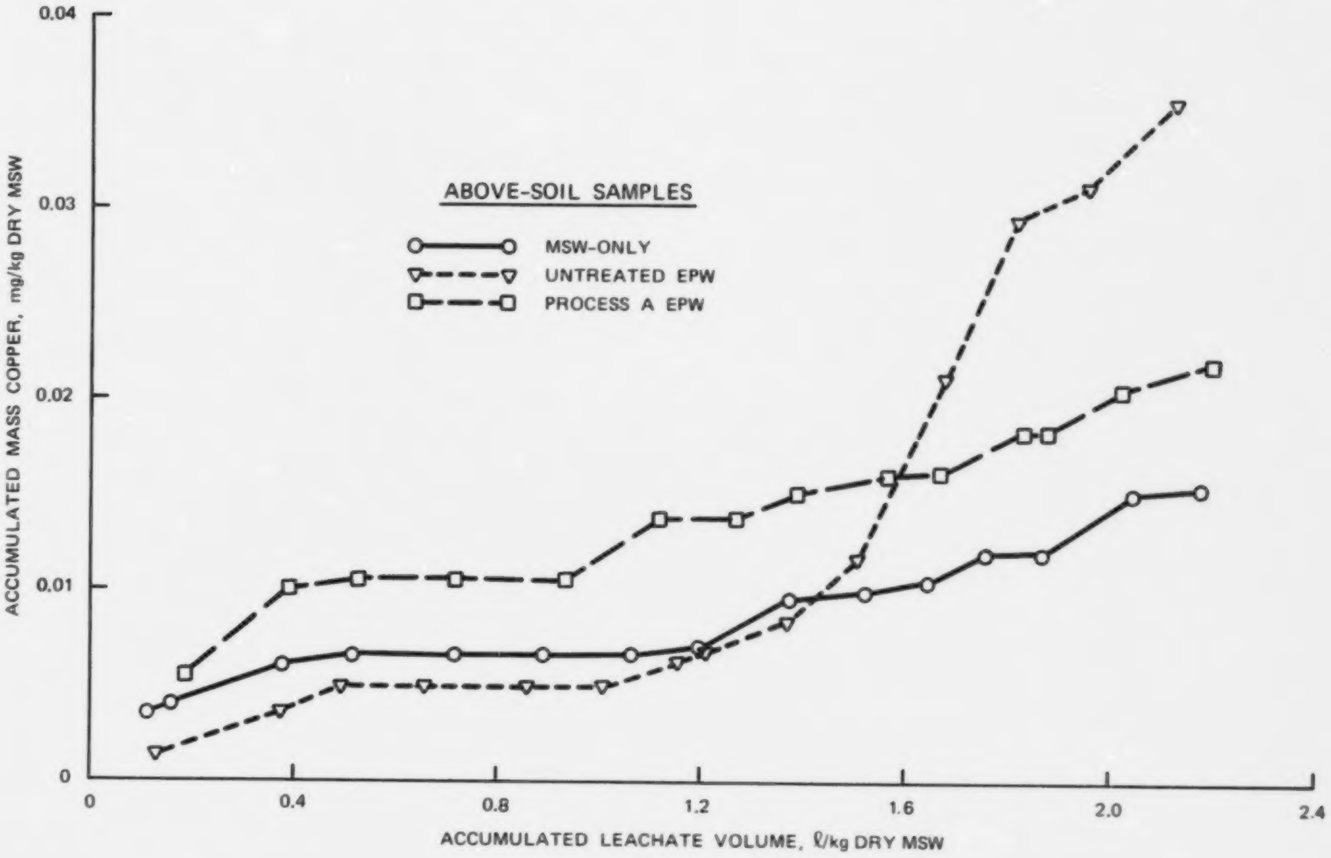

Figure 34. Plot of copper by volume for above-soil, EPW leachates.

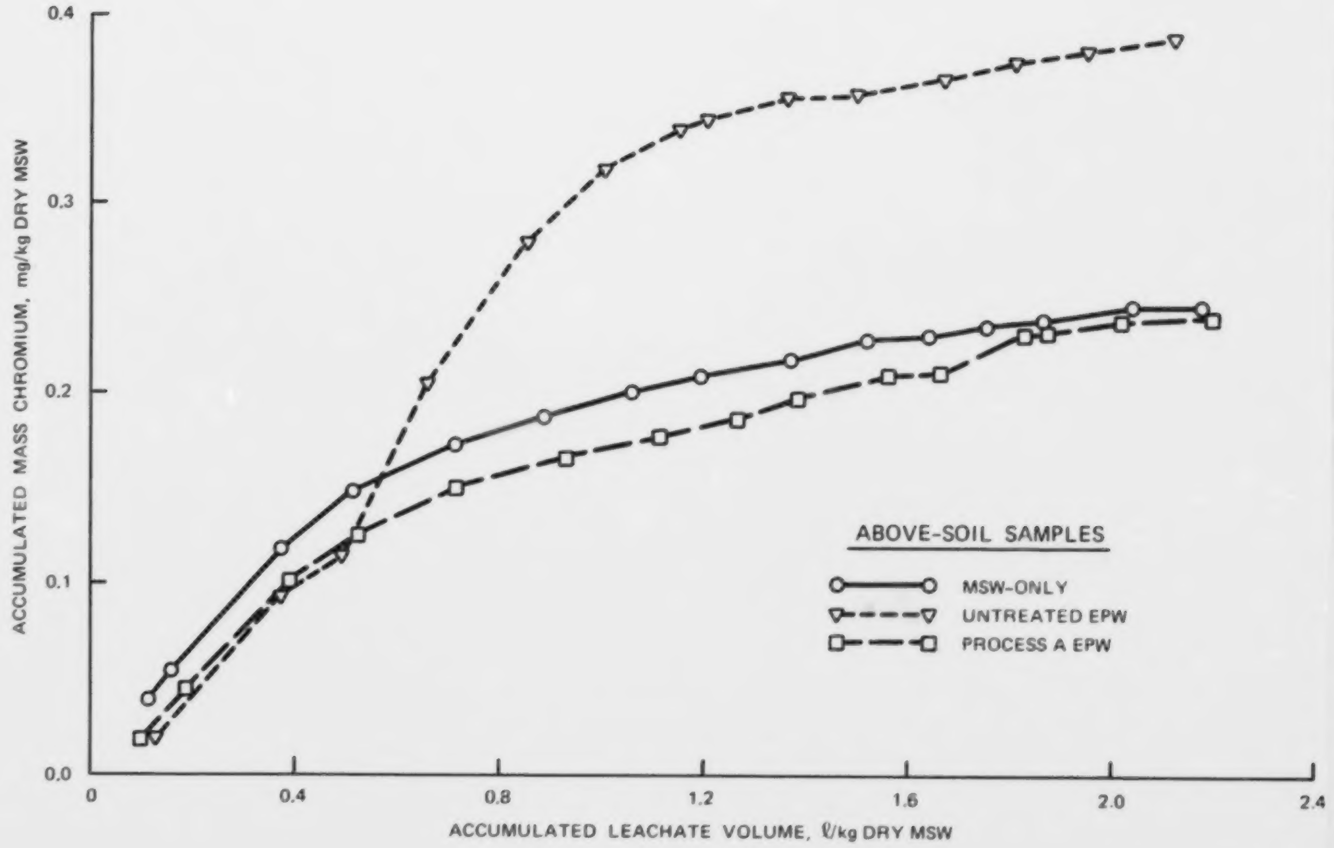

Figure 35. Plot of chromium by volume for above-soil leachates.

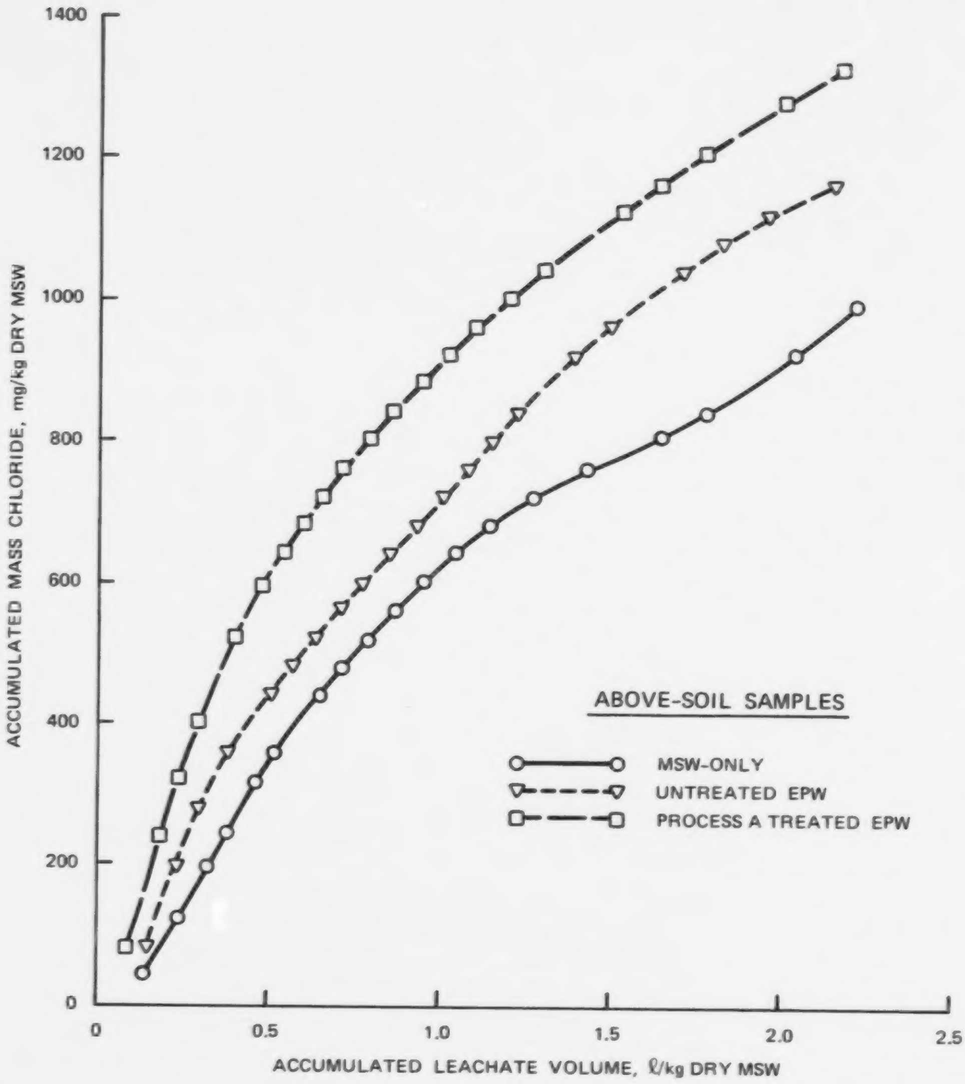

Figure 36. Plot of accumulated mass of chloride by accumulated leachate volume for above-soil leachate samples.

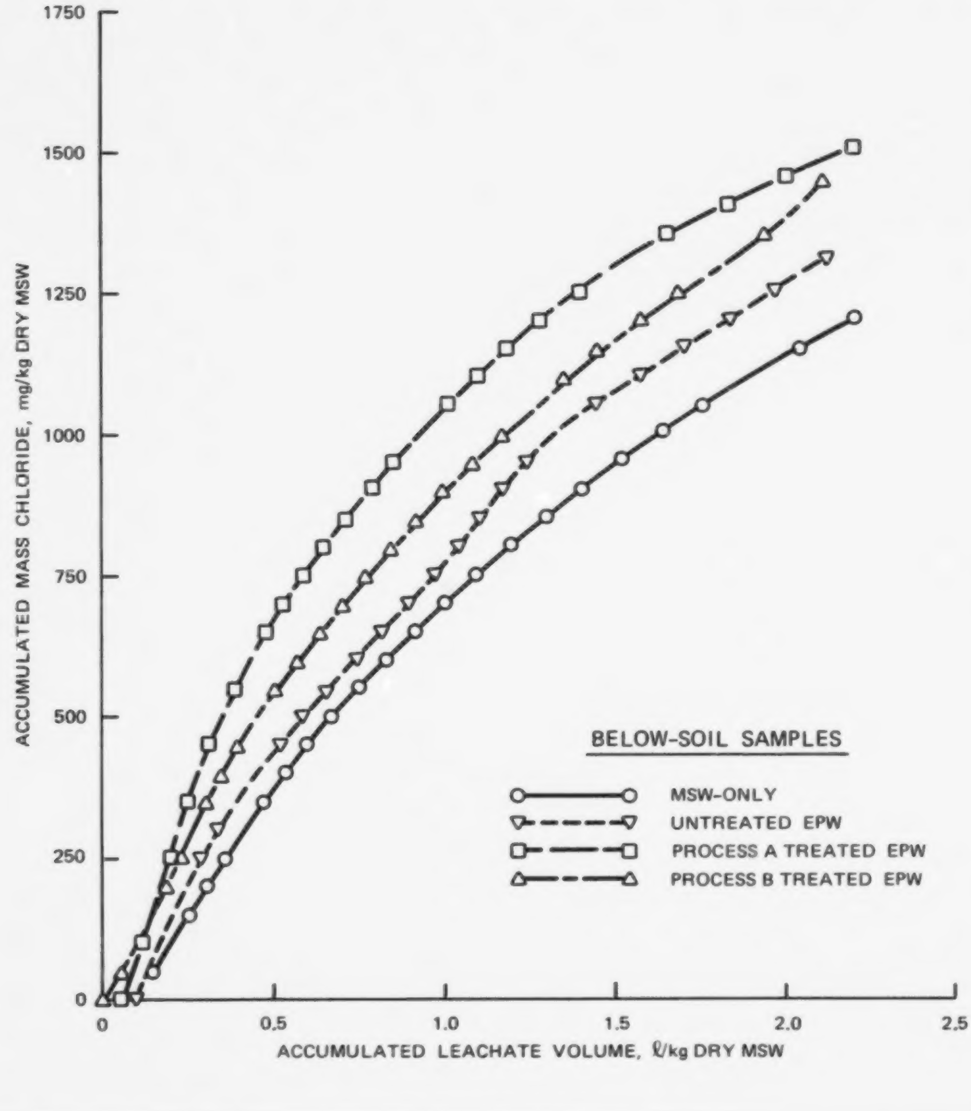

Figure 37. Plot of accumulated mass of chloride by accumulated leachate volume for below soil leachate samples.

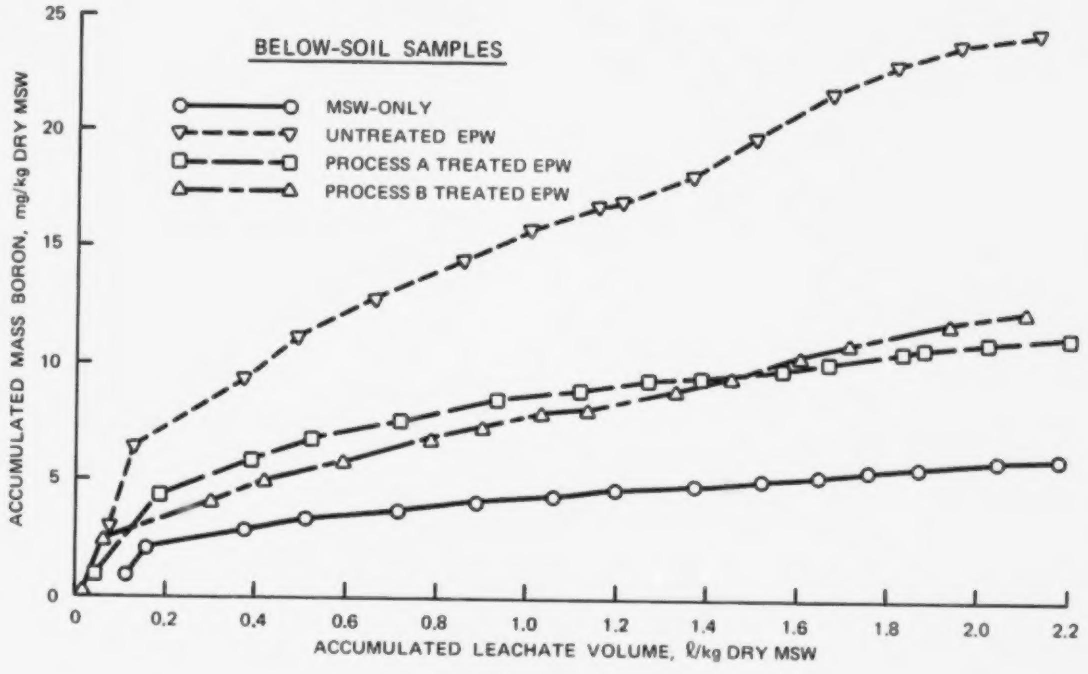

Figure 38. Plot of boron by volume for below-soil leachates.

Treated EPW-MSW Leachate Characteristics

The leachates from test cells containing treated wastes are more typical of the leachates from the MSW-only test cells for most constituents than of those of the untreated EPW-MSW test cell leachates. COD and BOD levels as well as their ratios are closer to literature values for typical, young leachates (31). The oxygen demands, TOC, TKN and alkalinity and pH values for the treated EPW leachates are quite similar to those of the MSW- only leachates, being within 10 to 20% in most cases. Exceptions are consistently higher levels of calcium, potassium and nickel from the treated-EPW leachates.

Process A Treated EPW Leachates -- For leachate samples taken above the soil layer from test cells containing EPW treated by Process A, the majority of constituent were leached at average concentrations the same or slightly higher than from the MSW-only test cells. This is seen by comparing the ratios in Tables 26 and 27. Constituents leached at concentrations within 10% of that of the MSW-only leachates in above soil samples are aluminum, cadmium, chromium, iron, manganese, COD, BOD, alkalinity and TKN. The majority of constituents are found at slightly higher levels (between 120 and about 200% of the MSW-only levels)--copper, lead, mercury, nickel, selenium, calcium, potassium, sodium, boron, chloride, fluoride, total organic carbon and total volatile acids. Constituents leached at less than 90% of the concentration in the MSW-only leachates were zinc, arsenic and total phosphate.

Below soil leachate samples from Process A treated EPW containing test cells were even more typical of the values found for MSW-only test cell leachates. Likewise, the total masses of the constituents leached and the highest concentrations found follow essentially the same patterns of constituent composition.

Process B treated EPW leachates--Comparison of leachates from test cells containing EPW treated by Process B are complicated by the lack of above soil data due to failure of the collection system. However, as seen above, below soil values which are available compare closely with relative values for above soil samples (Cf. Figures 30 and 31, and Figures 36 and 37). With very few exceptions, average, highest and total mass leached values are similar to those of the MSW-only and Process A treated EPW test cell leachates. The only constituents for which differences of greater than about 15% between constituent levels in the leachates from the two treated EPW leachates are aluminum and chromium which are about 50% lower in the process B leachates than in the process A, and cadmium, zinc, and total phosphate which are about 50% higher.

CHLORINE PRODUCTION BRINE (CPB) CODISPOSAL

The chlorine production brine (no. 800) is a tan, granular material with greater than 0.5% of calcium, silicon, sodium, chlorine and sulfate. Other elements found at greater than 100 mg/kg dry sludge solids were aluminum, boron, chromium, copper, iron, magnesium, manganese, mercury, potassium and zinc. The complete bulk analysis is given in Table 2 and Appendix A. Test cell 20 contained 2041 kg (dry wt) MSW and 2845 kg wet wt (1678 kg dry sludge solids) of untreated CPB in two layers. Test cell 17 contained 2036 kg (dry wt) MSW and 2609 kg of CPB solidified by Process A (1020 kg dry sludge solids) and test cell 12, 2043 kg (dry wt) MSW and 2302 kg of treated CPB treated by Process B (575 kg dry sludge solids).

Moisture Retention and Leachate Volumes

The amount of leachate collected at each sampling time is shown in Table 32. A total of 2.04 l of leachate/kg dry MSW was produced over the 1510 day experiment in the test cell containing the untreated CPB (cell 20); and 2.07 and 2.22 l/kg dry MSW collected from test cells containing CPB treated by Processes A and B respectively (cells 17 and 12). About 3 l of leachate was collected from each test cell per day. Although the amounts collected were variable in the short term, the leachates were quite consistently produced over the 1510 day study.

Again, patterns of leachate retention (Table 32) for the CPB containing test cells are quite consistent with those seen for the MSW-only test cells. Volumes retained in the waste averaged between 500 and 600 ml/kg dry MSW over about the first year of leachate collection. The retained moisture then slowly increased over the rest of the study until between 1300 and 1500 ml of leachate were retained by the end of the study.

Untreated CPB-MSW
Leachate Characteristics

The average values of all leachate parameters determined for the test cells containing treated and untreated CPB are compared to the MSW-only values for above-soil samples in Table 33 and for below-soil samples in Table 34. The corresponding values for the highest level of each parameter found and the total mass leached are shown in Tables 35 through 38.

The most dramatic effect of the added CPB is the greatly increased levels of sodium and chloride (Figures 39 and 40), as might be expected from their high solubility and their high levels in the CPB. Both are found with average levels 40 to 50 times those found in the MSW-only leachates--over 4.5% sodium chloride in the average leachate by weight. Both sodium and chloride averaged around 20,000 to 25,000 mg/l with highest concentrations found of 86,000 and 60,000 mg/l respectively.

A second effect is also apparent in the leachates: as can be seen in Figures 39 and 40, the leaching rates over the first one or two years are extremely high for both ions fall rapidly after this time until only relatively small amounts of both are being lost from the untreated CPB test cells by the end of the experiment. The drop in the rate of sodium leaching is due to its depletion in the added CPB in the test cell: 117.5 kg of sodium was loaded in the test cell (7% of the 1678 kg of dry CPB solids) and of this amount, a total of 108 kg of sodium had been leached over the experiment. This is 92% of the added sodium leached in less than 3 years. In contrast, although 83.5 kg of chloride was also lost to leaching during this time, it represents only about 31% of the chloride loaded into the test cell (268 kg). Other less chlorides must also be present in the CPB.

Marked decreases in rate of loss from the test containing untreated CPB are also seen at this same time (around day 1000) in other parameters. Overall conductivity values and most organic constituents such as TOC, TVA, COD

TABLE 32. VOLUMES OF LEACHATE COLLECTED AND RETAINED BY TEST CELLS CONTAINING CPB

Sample Day	Volume Produced Untr. (20)	A (17)	B (12)	Volume Retained Untr. (20)	A (17)	B (12)
247	155.0	189.0	107.0	0.50	0.49	0.52
282	0.0	0.0	0.0	0.58	0.57	0.61
303	63.2	85.9	119.2	0.60	0.57	0.60
331	0.0	0.0	0.0	0.67	0.64	0.66
359	250.2	132.9	133.2	0.61	0.64	0.66
388	150.5	156.6	135.7	0.60	0.63	0.66
437	145.3	173.7	153.7	0.65	0.66	0.70
458	127.3	0.0	0.0	0.63	0.71	0.75
486	99.6	135.5	146.9	0.65	0.71	0.75
514	108.6	107.1	143.9	0.66	0.72	0.74
542	101.8	119.7	169.4	0.68	0.73	0.72
570	114.3	114.7	134.8	0.69	0.74	0.72
598	121.1	142.7	136.3	0.69	0.73	0.72
633	135.5	154.4	160.5	0.71	0.74	0.72
664	124.8	32.9	106.7	0.72	0.80	0.74
689	139.6	161.2	119.0	0.71	0.78	0.74
724	124.2	100.6	134.7	0.73	0.81	0.76
752	97.3	61.3	127.4	0.75	0.84	0.76
780	137.7	122.6	105.9	0.75	0.85	0.78
815	90.1	117.0	65.5	0.78	0.87	0.83
843	82.1	94.6	103.7	0.81	0.89	0.84
878	102.6	102.2	95.4	0.84	0.93	0.88
906	59.8	100.3	110.5	0.88	0.94	0.89
934	93.5	99.2	115.4	0.90	0.96	0.90
969	0.0	0.0	0.0	0.98	1.04	0.98
1053	313.8	404.2	369.7	1.02	1.04	0.99
1150	205.9	235.0	260.4	1.15	1.15	1.09
1235	304.2	334.6	262.5	1.20	1.19	1.16
1328	217.0	143.5	190.8	1.31	1.33	1.29
1415	206.7	168.8	494.7	1.41	1.45	1.25
1510	300.9	419.1	327.5	1.48	1.47	1.31
Total	4172	4209	4530			

NOTE: Volume produced in l.
Volume retained in l/kg dry MSW.

TABLE 33. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR ABOVE SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW Only	MSW+CPB			MSW+CPB/MSW-Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.459	9.76	0.682	N*	21.27	1.48	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0039	0.110	0.0036	N	28.3	0.927	N
Chromium	0.128	0.147	0.110	N	1.15	0.85	N
Copper	0.010	0.055	0.037	N	5.28	3.54	N
Iron	323.	74.7	305.	N	0.23	0.94	N
Lead	0.036	0.098	0.039	N	2.69	1.08	N
Manganese	10.0	9.51	11.8	N	0.95	1.18	N
Mercury	0.0010	0.0157	0.0011	N	15.09	1.06	N
Nickel	0.229	0.319	0.286	N	1.39	1.24	N
Selenium	0.104	0.375	0.119	N	3.60	1.14	N
Zinc	7.90	16.4	16.6	N	2.08	2.11	N
Calcium	520.	729.	884.	N	1.40	1.70	N
Magnesium	86.9	224.	131.	N	2.59	1.52	N
Potassium	326.	468.	590.	N	1.44	1.81	N
Sodium	377.	19241.	3398.	N	50.9	8.99	N
Arsenic	0.085	0.104	0.043	N	1.22	0.50	N
Boron	2.38	3.76	3.69	N	1.57	1.55	N
Chloride	567.	24895.	4470.	N	43.8	7.88	N
Fluoride	0.156	3.41	1.19	N	21.8	7.61	N
COD	18385.	16234.	22269.	N	0.88	1.21	N
BOD	11922.	9884.	14686.	N	0.83	1.23	N
BOD/COD	0.65	0.61	0.66	N	-	-	-
COD/TOC	3.06	2.84	2.95	N	-	-	-
TOC	6004.	5709.	7548.	N	0.95	1.26	N
Alkalinity	2642.	4439.	2997.	N	1.68	1.13	N
pH	5.31	6.19	5.33	N	1.17	1.00	N
Vol. Acids	1281.	2199.	2920.	N	1.72	2.28	N
Tk Nitrogen	542.	490.	628.	N	0.90	1.16	N
Phosphate	22.6	7.25	15.3	N	0.32	0.68	N
Volume (l/mo)	143.	134.	135.	N	0.94	0.95	N

* N = No data or all values below detection limits.

TABLE 34. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW	MSW+CPB			MSW+CPB/MSW-Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	1.70	12.6	1.04	0.562	7.39	0.61	0.33
Beryllium	0.014	N*	0.014	0.013	N	0.96	0.89
Cadmium	0.0041	0.118	0.0037	0.0041	29.1	0.91	1.01
Chromium	0.100	0.112	0.079	0.177	1.11	0.79	1.76
Copper	0.012	0.039	0.015	0.018	3.32	1.30	1.56
Iron	396.	74.4	371.	364.	0.19	0.94	0.92
Lead	0.016	0.117	0.032	0.049	7.41	2.04	3.14
Manganese	11.9	9.41	11.5	12.6	0.79	0.97	1.06
Mercury	0.0029	0.0042	0.0039	0.0033	1.47	1.36	1.15
Nickel	0.236	0.243	0.264	0.273	1.02	1.11	1.15
Selenium	0.071	0.283	0.144	0.186	3.98	2.02	2.62
Zinc	8.24	15.2	10.9	7.43	1.84	1.32	0.90
Calcium	618.	648.	891.	819.	1.05	1.44	1.33
Magnesium	105.	234.	128.	212.	2.21	1.22	2.01
Potassium	395.	466.	612.	564.	1.18	1.55	1.42
Sodium	535.	23084.	3395.	2498.	43.1	6.34	4.67
Arsenic	0.045	0.077	0.045	0.130	1.70	1.00	2.88
Boron	2.82	3.11	4.05	21.9	1.10	1.43	7.76
Chloride	672.	39363.	4477.	4273.	43.6	6.66	6.36
Fluoride	0.347	1.40	0.850	0.324	4.04	2.44	0.93
COD	23216.	17757.	21678.	22814.	0.76	0.93	0.98
BOD	12183.	8868.	15005.	13042.	0.73	1.23	1.07
BOD/COD	0.52	0.50	0.69	0.57	-	-	-
COD/TOC	3.25	3.01	3.03	2.91	-	-	-
TOC	7145.	5895.	7152.	7842.	0.83	1.00	1.10
Alkalinity	2555.	4285.	2931.	3023.	1.68	1.15	1.18
pH	5.34	6.18	5.38	5.45	1.16	1.01	1.02
Vol. Acids	1709.	3104.	2467.	4124.	1.82	1.44	2.41
Tk Nitrogen	633.	495.	580.	607.	0.78	0.92	0.96
Phosphate	3.14	3.90	5.01	6.89	1.24	1.60	2.20
Volume (l/mo)	143.	134.	135.	146.	0.94	0.95	1.02

* N = No data or all values below detection limits.

TABLE 35. HIGHEST CONCENTRATIONS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR ABOVE-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW Only	MSW + CPB			MSW+CPB/MSW Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	2.00	86.5	3.98	N*	43.2	1.99	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0219	0.542	0.0173	N	24.7	0.79	N
Chromium	0.338	0.435	0.260	N	1.28	0.76	N
Copper	0.030	0.301	0.250	N	10.0	8.33	N
Iron	713.	208.	430.	N	0.29	0.60	N
Lead	0.158	0.879	0.235	N	5.56	1.48	N
Manganese	18.6	30.7	18.0	N	1.65	0.96	N
Mercury	0.0023	0.135	0.0028	N	58.8	1.21	N
Nickel	0.483	1.14	0.427	N	2.36	0.88	N
Selenium	0.160	0.780	0.220	N	4.87	1.37	N
Zinc	21.7	42.3	40.0	N	1.94	1.84	N
Calcium	1117.	1752.	1082.	N	1.57	0.97	N
Magnesium	177.	485.	185.	N	2.73	1.04	N
Potassium	615.	1025.	877.	N	1.67	1.43	N
Sodium	942.	86000.	6030.	N	91.2	6.40	N
Arsenic	0.280	0.132	0.078	N	0.47	0.27	N
Boron	8.09	13.3	8.79	N	1.64	1.08	N
Chloride	1063.	60029.	5789.	N	56.4	5.45	N
Fluoride	0.349	7.43	5.57	N	21.2	15.9	N
COD	32600.	38000.	32930.	N	1.17	1.01	N
BOD	25000.	60000.	26000.	N	2.40	1.04	N
TOC	12000.	13000.	13000.	N	1.08	1.08	N
Alkalinity	8000.	8200.	6190.	N	1.02	0.77	N
pH	6.20	7.60	5.80	N	1.23	0.94	N
Vol. Acids	3715.	8380.	9190.	N	2.26	2.47	N
Tk Nitrogen	881.	1090.	910.	N	1.24	1.03	N
Phosphate	31.4	18.7	23.9	N	0.60	0.76	N

* N = No data or all values below detection limits.

TABLE 36. HIGHEST CONCENTRATIONS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW	MSW + CPB			MSW+CPB/MSW Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	14.9	122.	10.1	2.65	8.18	0.67	0.17
Beryllium	0.017	N*	0.015	0.013	N	0.85	0.74
Cadmium	0.018	0.607	0.0127	0.0241	32.8	0.686	1.30
Chromium	0.361	0.335	0.273	0.584	0.92	0.75	1.61
Copper	0.040	0.148	0.037	0.050	3.70	0.93	1.25
Iron	1470.	345.	540.	873.	0.23	0.37	0.59
Lead	0.052	1.010	0.114	0.375	19.4	2.19	7.21
Manganese	23.1	25.2	24.1	26.2	1.09	1.04	1.13
Mercury	0.0055	0.0208	0.0288	0.0130	3.78	5.23	2.36
Nickel	0.468	0.738	0.670	0.973	1.57	1.43	2.07
Selenium	0.125	0.390	0.228	0.348	3.12	1.82	2.78
Zinc	19.0	34.5	20.5	24.8	1.81	1.07	1.30
Calcium	1372.	1870.	1502.	1225.	1.36	1.09	0.89
Magnesium	222.	572.	290.	390.	2.58	1.30	1.75
Potassium	787.	1015.	1375.	1162.	1.29	1.75	1.48
Sodium	1142.	111500.	4700.	5125.	97.59	4.11	4.49
Arsenic	0.140	0.223	0.095	0.505	1.59	0.67	3.60
Boron	8.74	8.20	18.70	55.5	0.93	2.14	6.35
Chloride	1322.	76802.	6180.	6685.	58.1	4.67	5.06
Fluoride	0.775	5.50	3.00	0.738	7.09	3.87	0.95
COD	66800.	63400.	56200.	46500.	0.95	0.84	0.70
BOD	32000.	49000.	41000.	32100.	1.53	1.28	1.00
TOC	13500.	13000.	18000.	17500.	0.96	1.33	1.30
Alkalinity	5200.	8000.	5690.	5750.	1.54	1.09	1.11
pH	6.00	8.00	6.00	6.10	1.33	1.00	1.02
Vol. Acids	9740.	11100.	6800.	30700.	1.14	0.70	3.15
Tk Nitrogen	966.	948.	1320.	2280.	0.98	1.37	2.36
Phosphate	4.90	11.6	25.2	12.9	2.37	5.14	2.63

* N = No data or all values below detection limits.

TABLE 37. TOTAL MASS LEACHED PER KG DRY MSW AND RATIOS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR ABOVE-SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW Only	MSW + CPB			MSW+CPB/MSW Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.915	14.8	1.18	N*	16.2	1.29	N
Beryllium	N	N	N	N	N	N	N
Cadmium	0.0072	0.159	0.0064	N	22.2	0.89	N
Chromium	0.242	0.228	0.226	N	0.94	0.93	N
Copper	0.015	0.100	0.064	N	6.63	4.23	N
Iron	779.	110.	639.	N	0.14	0.82	N
Lead	0.054	0.096	0.061	N	1.79	1.14	N
Manganese	21.8	19.7	23.7	N	0.90	1.09	N
Mercury	0.0005	0.0303	0.0003	N	61.6	0.60	N
Nickel	0.505	0.632	0.584	N	1.25	1.15	N
Selenium	0.057	0.180	0.057	N	3.17	1.01	N
Zinc	14.7	15.5	29.9	N	1.05	2.03	N
Calcium	1117.	1549.	1797.	N	1.39	1.61	N
Magnesium	189.	447.	264.	N	2.36	1.40	N
Potassium	723.	928.	1202.	N	1.28	1.66	N
Sodium	838.	39417.	6775.	N	47.01	8.08	N
Arsenic	0.102	0.048	0.035	N	0.46	0.34	N
Boron	4.94	7.20	7.27	N	1.45	1.47	N
Chloride	995.	36387.	7154.	N	36.5	7.18	N
Fluoride	0.191	0.758	0.659	N	3.97	3.45	N
COD	38405.	31771.	43767.	N	0.83	1.14	N
BOD	25203.	17816.	29367.	N	0.71	1.17	N
BOD/COD	0.66	0.56	0.67	N	0.85	1.02	N
COD/TOC	3.67	4.90	3.55	N	1.33	0.97	N
TOC	10471.	6489.	12320.	N	0.62	1.18	N
Alkalinity	5849.	7469.	6119.	N	1.28	1.05	N
Vol. Acids	2387.	4427.	5378.	N	1.85	2.25	N
Tk Nitrogen	1191.	835.	1260.	N	0.70	1.06	N
Phosphate	50.1	12.3	31.9	N	0.25	0.64	N

* N = No data or all values below detection limits.

TABLE 38. TOTAL MASS LEACHED PER KG DRY MSW AND RATIOS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED CHLORINE PRODUCTION BRINE (800) FOR BELOW-SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW	MSW + CPB			MSW+CPB/MSW Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	3.03	29.9	1.77	0.897	9.90	0.58	0.29
Beryllium	0.007	N*	0.004	0.001	N	0.524	0.102
Cadmium	0.0073	0.176	0.0048	0.0052	24.2	0.65	0.70
Chromium	0.196	0.192	0.159	0.330	0.98	0.81	1.68
Copper	0.018	0.073	0.027	0.017	4.16	1.50	0.96
Iron	1007.	139.	759.	909.	0.14	0.75	0.90
Lead	0.022	0.115	0.038	0.057	5.22	1.73	2.60
Manganese	25.8	21.2	23.4	26.7	0.82	0.90	1.03
Mercury	0.0018	0.0064	0.0036	0.0018	3.62	2.01	1.00
Nickel	0.522	0.547	0.518	0.533	1.04	0.99	1.02
Selenium	0.031	0.155	0.047	0.087	5.05	1.53	2.83
Zinc	15.1	13.5	20.1	12.7	0.89	1.33	0.84
Calcium	1338.	1611.	1813.	1716.	1.20	1.35	1.28
Magnesium	230.	510.	258.	471.	2.22	1.12	2.05
Potassium	876.	1028.	1248.	1201.	1.17	1.42	1.37
Sodium	1178.	52911.	6889.	5819.	44.9	5.85	4.94
Arsenic	0.046	0.092	0.054	0.268	2.02	1.18	5.86
Boron	5.83	6.77	7.76	47.8	1.16	1.33	8.19
Chloride	1175	40925.	7114.	6944.	34.8	6.05	5.91
Fluoride	0.471	1.19	0.448	0.391	2.53	0.95	0.83
COD	50151.	40706.	44128.	48331.	0.81	0.88	0.96
BOD	26581.	18477.	29575.	27005.	0.70	1.11	1.02
BOD/COD	0.53	0.45	0.67	0.56	0.86	1.26	1.05
COD/TOC	4.12	4.73	3.84	3.62	1.15	0.93	0.88
TOC	12164.	8603.	11506.	13337.	0.71	0.95	1.10
Alkalinity	5328.	8106.	5723.	6326.	1.52	1.07	1.19
Vol. Acids	3931.	6772.	4405.	9868.	1.72	1.12	2.51
Tk Nitrogen	1401.	1034.	1184.	1098.	0.74	0.85	0.78
Phosphate	5.45	7.37	9.80	13.2	1.35	1.80	2.43

* N = No data or all values below detection limits.

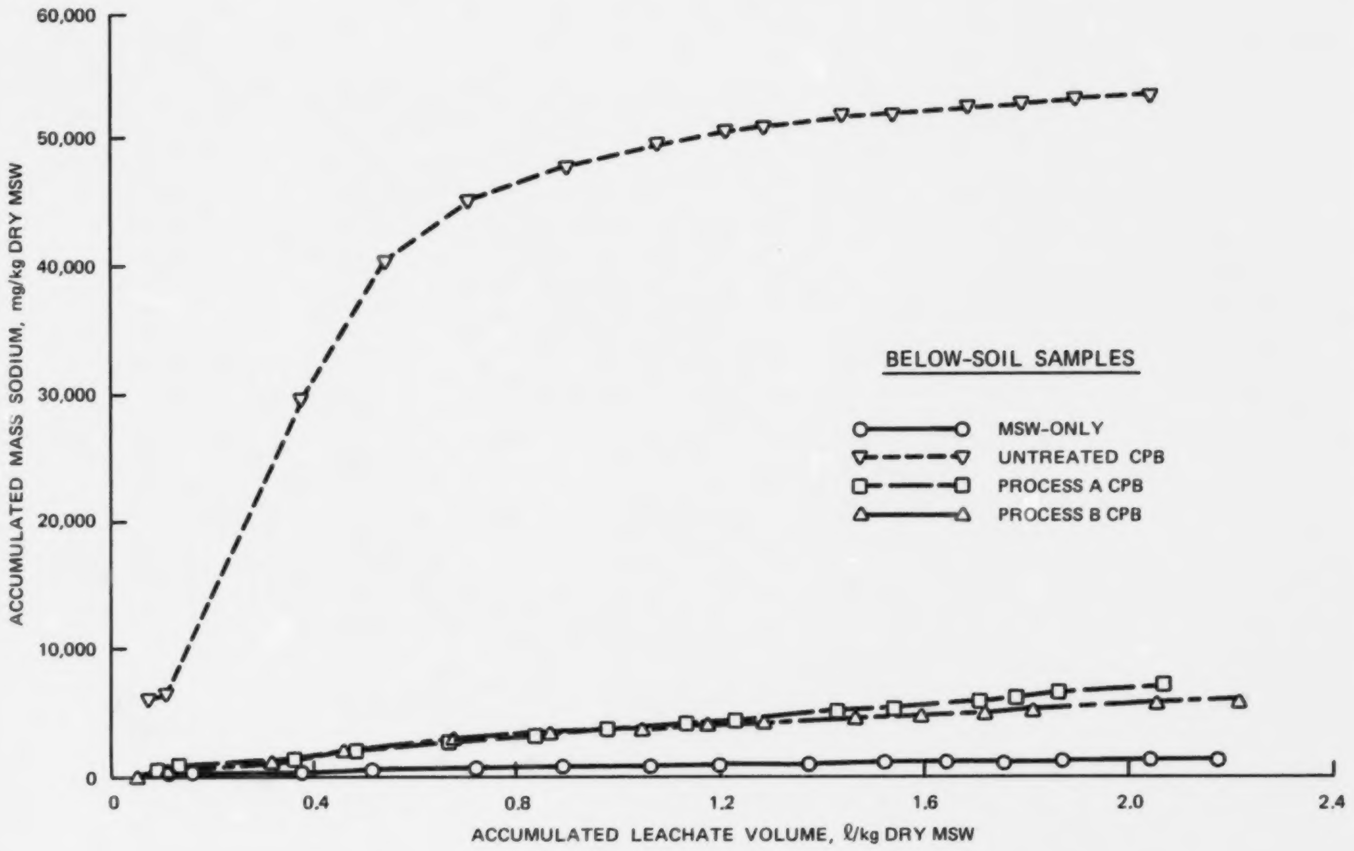

Figure 39. Plot of sodium by volume for below-soil, CPB leachates.

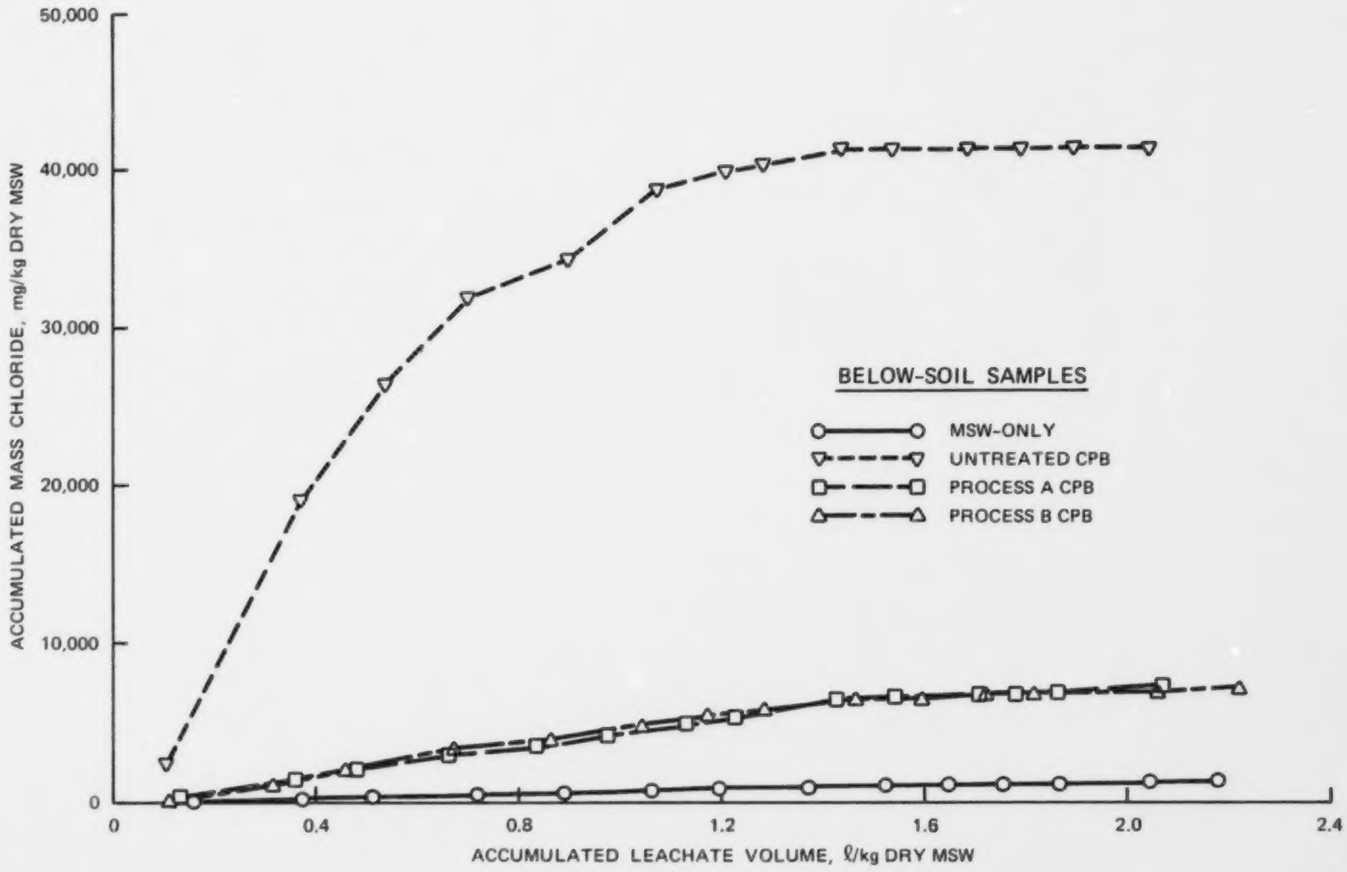

Figure 40. Plot of chloride by volume for below-soil, CPB leachates.

(Fig. 41) and BOD (Fig. 42) all fall rapidly. pH values also increase gradually over this time from about 6.0 to 7.5 or higher in the below-soil leachate samples. Levels of calcium in the untreated CPB-MSW leachates also decline rapidly at this time (Fig. 43). Iron concentrations in the untreated EPW-MSW leachates were also held to very low levels throughout the experiment (Fig. 44) due possibly to the decrease in iron reducing bacterial activity because of the high ionic strength of the leachate. Levels of several other metals (e.g., potassium, manganese, and zinc) also follow this pattern. Values for above-soil leachate samples are quite similar to those illustrated which are all below-soil samples.

Even with this large decrease in losses to leaching in the last year or two of the study, larger total amounts of all constituents were lost from the untreated CPB-MSW test cell except chromium, iron, manganese and the nutrients TKN and total phosphate. In addition to the large excesses of sodium and chloride, other constituents such as aluminum, cadmium, copper and mercury were also especially high in the early leachates from the untreated CPB containing test cells.

Treated CPB-MSW Leachate Characteristics

Leachates from the test cells containing treated CPB are more similar to those of the MSW-only test cells than of the untreated CPB-MSW test cells. Both treatment systems held sodium and chloride to less than 10 times the MSW-only leachate levels in average concentration and less than 6 times the total masses leached. This is a reduction of 90 to 95% over the untreated CPB leachate values. These data are illustrated in Figures 39 and 40. Average levels of beryllium, cadmium, iron (Fig. 44), manganese, nickel COD (Fig. 41), TOC, alkalinity and TKN were within 10 to 15% of the MSW-only leachates for both treated CPB leachates for below-soil samples. pH values for leachates from both treated CPB-MSW test cells were also with 1 or 2% of those from the MSW-only test cells. Losses of calcium were also quite similar between the two test cells containing treated CPB (Fig. 43) although 30 to 45% higher than MSW-only leachates.

Process A Treated CPB-MSW Leachates--Of the 10 elements present in the CPB at concentrations greater than 100 mg/kg dry sludge solids (but less than 5000 mg/kg), 6 had average, above-soil concentrations greater than leachates from MSW-only leachates -- aluminum (148%), copper (354%), magnesium (152%), potassium (181%), zinc (211%) and boron (155%). All of these were lower than comparable untreated CPB-MSW leachate values except potassium, zinc and boron which were very nearly equal. The other 4 common elements had average concentrations with 15% of the MSW-only leachates (Chromium at 85%, iron at 94%, manganese at 115% and mercury at 106%).

Process B Treated CPB-MSW Leachates-- No above-soil samples were available for analysis from the test cell containing CPB treated by Process B so that below-soil values are used for comparison. Of the same 10 minor elements contained in the CPB, 5 had average, below-soil concentrations greater than leachates from the MSW-only leachates--chromium (176%), copper (156%), magnesium (201%), potassium (142%) and boron (776%). All others were within 10% of the MSW-only leachates except aluminum which has significant soil interaction so that the below-soil samples cannot be expected to be representative.

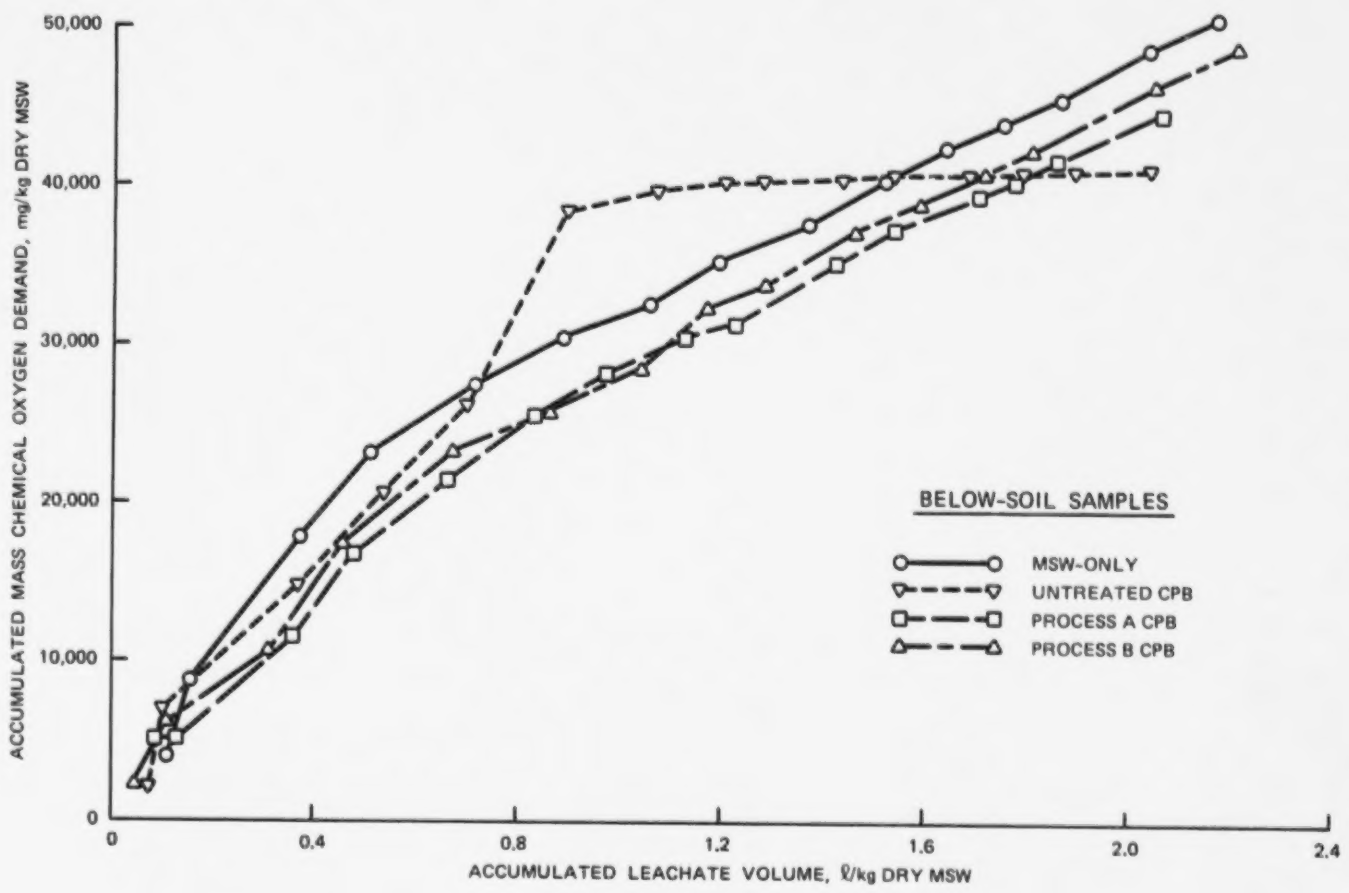

Figure 41. Plot of chemical oxygen demand by volume for below-soil, CPB leachates.

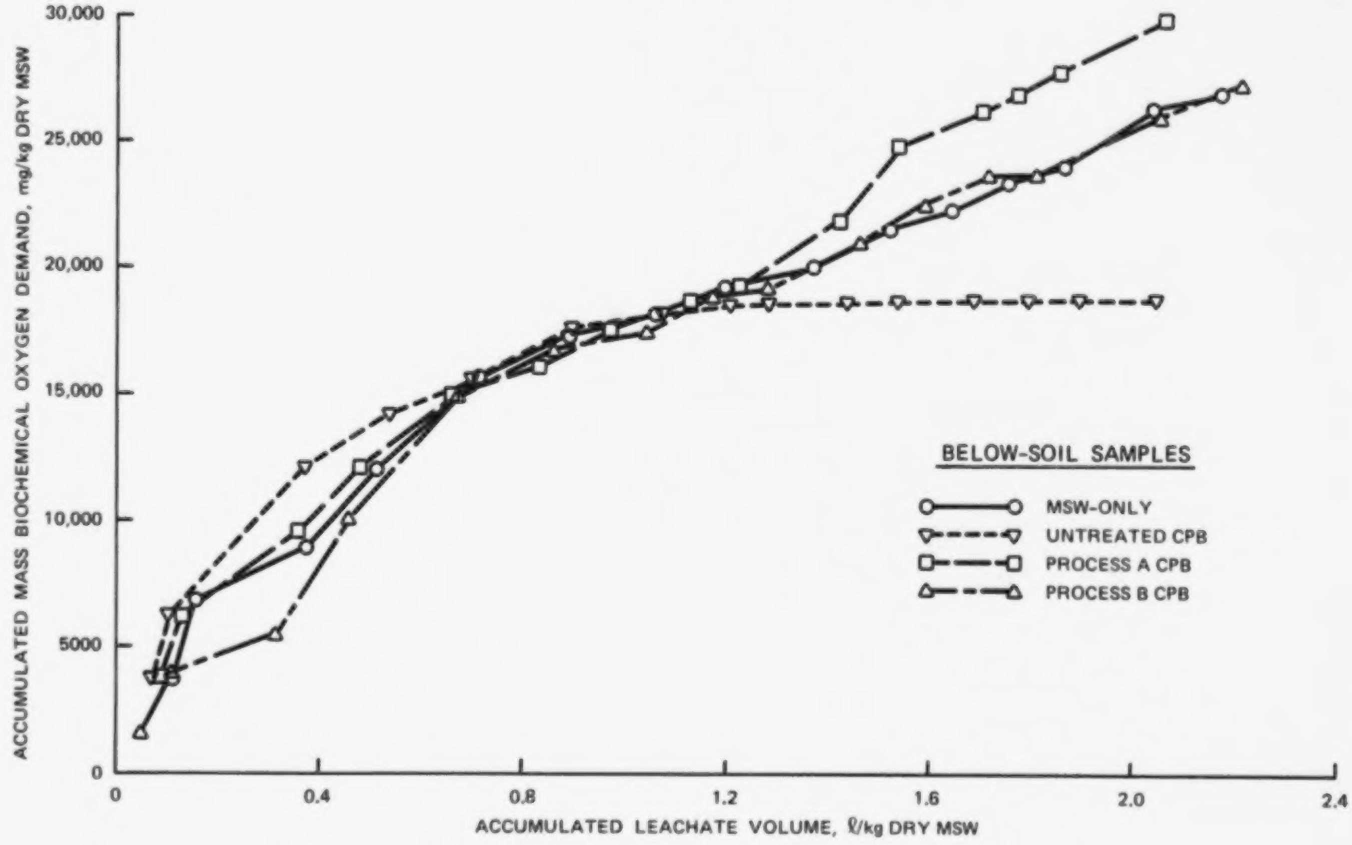

Figure 42. Plot of biochemical oxygen demand by volume for below-soil, CPB leachates.

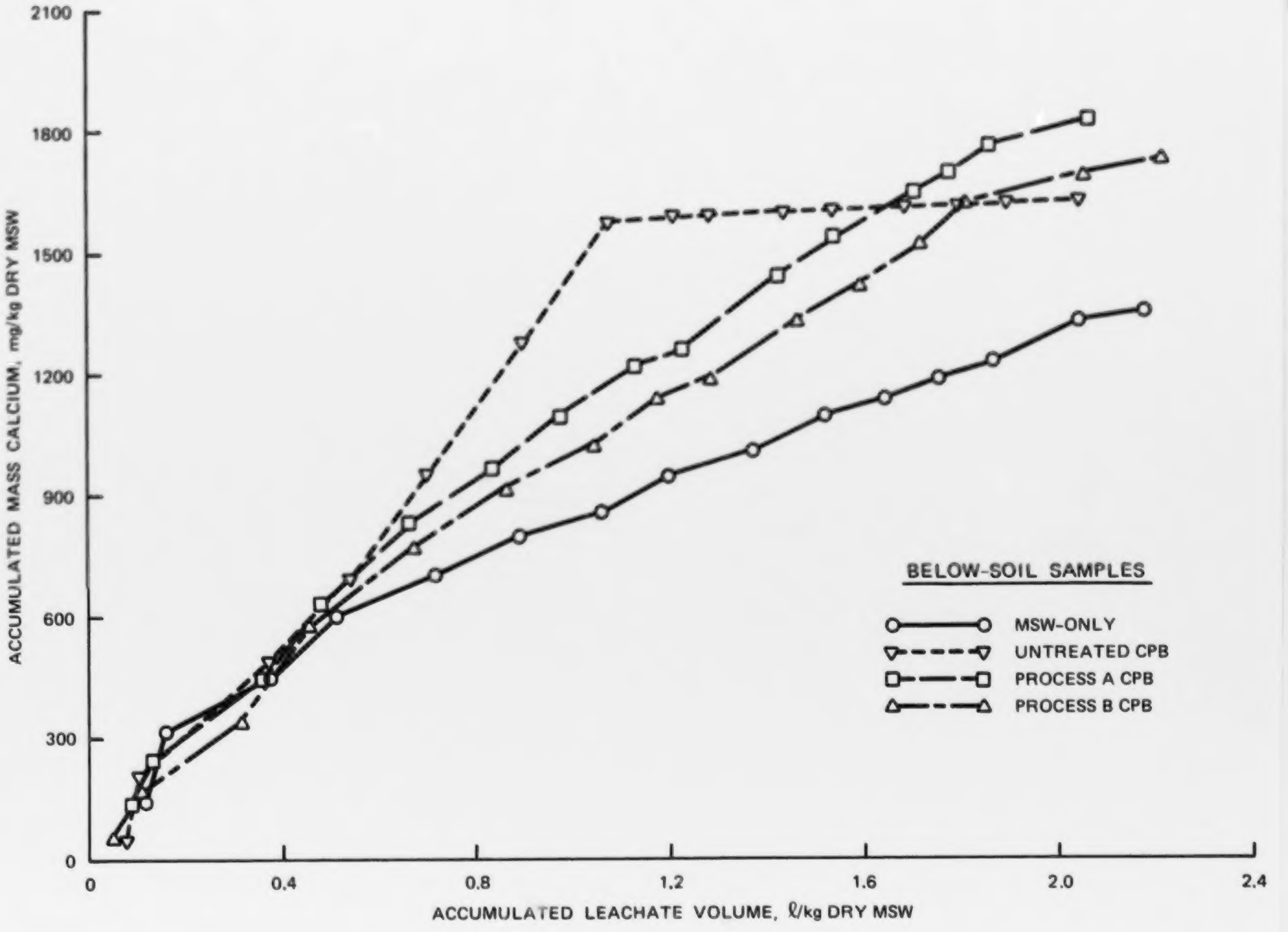

Figure 43. Plot of calcium by volume for below-soil, CPB leachates.

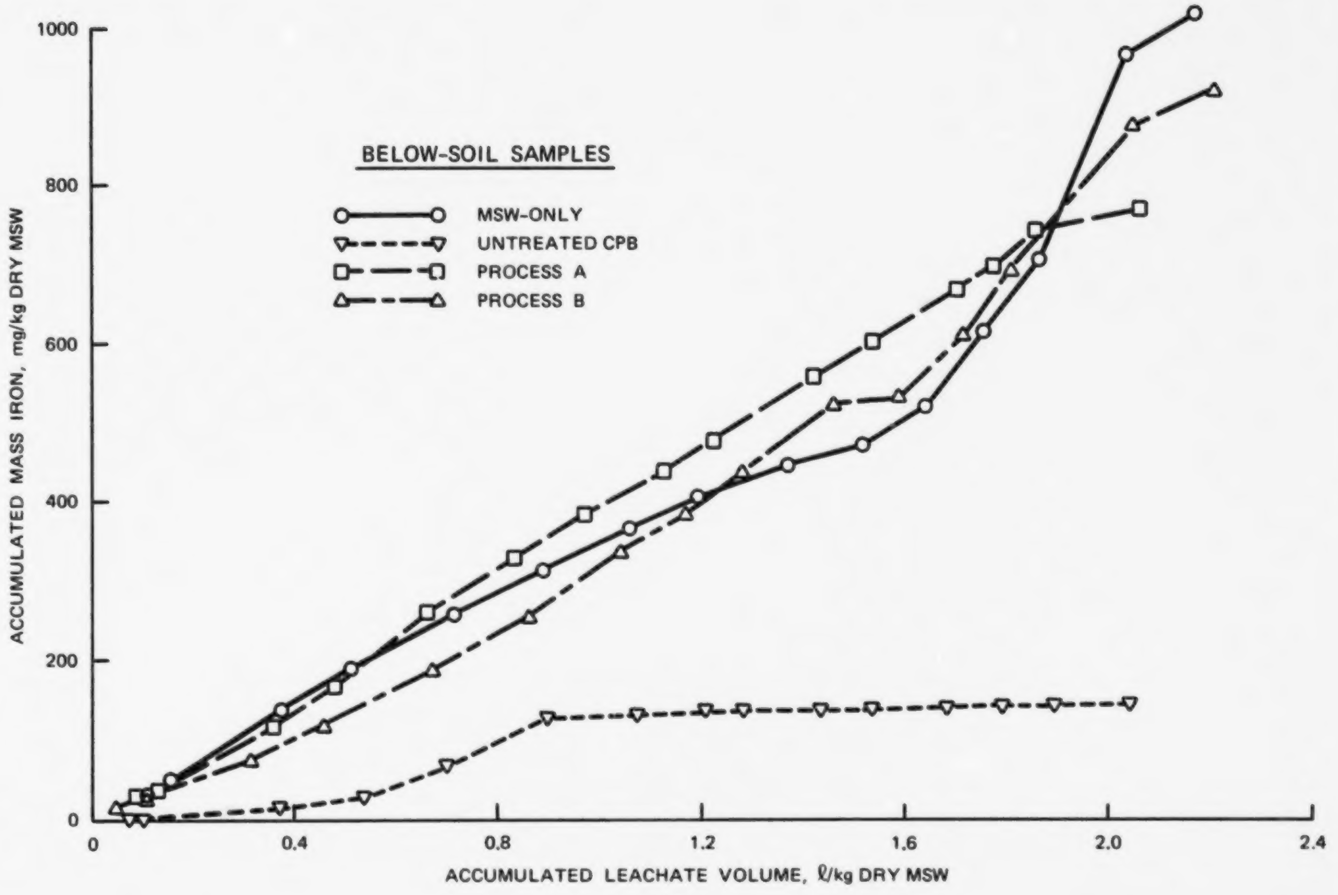

Figure 44. Plot of iron by volume for below-soil, CPB leachates.

GLASS AND ELECTRONICS ETCHING SLUDGE (GES) CO-DISPOSAL

The glass and electronics etching sludge (no. 900) is a light-brown sludge which contains greater than 1% of dry solids of aluminum, calcium, magnesium, silicon, chloride and sulfate. It also has a high concentration of fluoride which was not included in the bulk analysis, and lower levels (greater than 200 mg/l) of several cations--chromium, copper, iron, lead, nickel, potassium, sodium and zinc. The complete bulk analysis is given in Table 2 and in Appendix A. Test cell 21 contained 2039 kg dry wt of MSW and 2270 kg of wet, untreated GES (1303 kg dry sludge solids). GES treated by Process A was contained in test cell 18 which was loaded with 2045 kg dry wt of MSW and 2026 kg of treated GES (608 kg dry sludge solids) and GES treated by Process B in test cell 13 with 2031 kg dry wt MSW and 2282 kg treated waste (234 kg dry sludge solids).

Moisture Retention and Leachate Volumes

As seen in Table 39, moisture retention by the MSW in the test cell containing untreated GES (cell 21) is similar to that seen for all other test cells except that the amount of moisture retain at the end of the study was only 50 to 67% that of other test cells. This lower retention results from the slightly higher leachate production--43 l/kg dry MSW--for this test cell. It may reflect a much lower level of biological activity in this test cell as discussed below.

The two test cells containing treated GES produced much more leachate than any of the other test cells--2.86 l/kg dry MSW for cell 18 and 2.97 l/kg for cell 13. This is due to inadvertent leachant additions caused by faulty valves around day 500, and further smaller additions to cell 13 around days 900 and 1000. These unmeasured additions cause faulty leachate retention values from then on for both cells since the additions of unknown amounts cannot be calculated into the moisture budget. Other than these unknown additions the retention and production data follow a similar pattern to other test cells. The proportionately large leachate production values especially for test cell 13 must be taken into account in any discussion of the leaching data.

Untreated GES-MSW
Leachate Characteristics

The data for the levels of constituents in the leachates from these test cells is presented in an identical manner to the previous waste types with average values in Tables 40 and 41, highest values in Tables 42 and 43, and total masses leached in Tables 44 and 45. Results for the MSW-only test cell and ratios comparing results for each GES-containing test cell to those for the MSW-only are also given in each table.

Judging from the above-soil samples, the untreated GES appears to have the greatest effect upon the biological activity in the MSW of any of the waste types included in the study. COD (Fig. 45), BOD (Fig. 46), TOC and total volatile acids are all very low in these leachates, reaching to only about 30% of the average concentrations and about 25% of the total mass leached when compared to those in the MSW-only leachates. The average pH values in the untreated GES-MSW leachates are also the most basic seen, averaging 1.3 units higher. Both TKN and total phosphate are also lower in the GES

TABLE 39. VOLUMES OF LEACHATE COLLECTED AND RETAINED BY TEST CELLS CONTAINING GLASS-ELECTRONICS SLUDGE

Sample Day	Volume Produced Untr. (21)	A (18)	B (13)	Volume Retained Untr. (21)	A (18)	B (13)
247	137.0	83.0	197.0	0.51	0.54	0.48
282	0.0	0.0	0.0	0.59	0.62	0.57
303	35.6	166.2	79.5	0.62	0.58	0.58
331	0.7	0.0	0.0	0.69	0.65	0.64
359	166.6	128.3	185.9	0.67	0.65	0.62
388	122.7	179.7	163.8	0.68	0.63	0.60
437	139.7	453.4	229.8	0.73	0.53	0.60
458	110.2	0.0	0.0	0.72	0.57	0.65
486	44.3	203.7	371.3	0.77	0.54	0.54
514	70.8	194.2	438.4	0.80	0.51*	0.39*
542	243.4	282.0	478.8	0.74	0.44	0.22
570	148.4	208.2	671.9	0.74	0.40	-0.05
598	149.5	212.4	327.4	0.73	0.36	-0.14
633	74.9	201.7	137.4	0.77	0.35	-0.13
664	82.1	152.4	172.6	0.80	0.34	-0.14
689	96.1	149.1	141.3	0.82	0.33	-0.15
724	131.3	186.9	139.6	0.83	0.32	-0.14
752	138.9	101.1	139.5	0.83	0.33	-0.14
780	205.5	132.8	119.9	0.80	0.34	-0.13
815	101.1	123.4	99.9	0.83	0.36	-0.10
843	374.0	129.8	123.8	0.71	0.36	-0.10
878	151.4	113.9	106.4	0.72	0.38	-0.07
906	182.4	244.9	436.8	0.69	0.33	-0.22*
934	205.1	234.7	202.5	0.66	0.28	-0.25
969	0.0	0.0	0.0	0.74	0.36	-0.17
1053	492.8	396.6	777.8	0.70	0.36	-0.35*
1150	241.8	306.0	360.7	0.80	0.44	-0.31
1235	379.7	440.2	980.5	0.82	0.42	-0.59
1328	267.5	211.4	246.5	0.90	0.54	-0.49
1415	188.9	231.7	447.1	1.01	0.63	-0.51
1510	273.1	392.6	297.0	1.10	0.66	-0.43
Total	4955	5860	8073	-	-	-

NOTE: Volume produced in l.
Volume retained in l/kg dry MSW.

* Addition of undetermined amounts of leachant around this time causes all values after this time to be inaccurate. Numbers are given for relative stability estimation only.

TABLE 40. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR ABOVE-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW	MSW + GES			MSW+GES/MSW-Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.459	0.805	0.735	1.30	1.75	1.60	2.83
Beryllium	N*	N	0.020	0.013	N	N	N
Cadmium	0.0039	0.0136	0.0033	0.0050	3.47	0.85	1.28
Chromium	0.128	0.073	0.138	0.079	0.57	1.07	0.61
Copper	0.010	0.012	0.013	0.011	1.14	1.26	1.09
Iron	323.	87.6	318.	184.9	0.27	0.98	0.57
Lead	0.036	0.016	0.026	0.015	0.45	0.71	0.42
Manganese	10.0	19.2	10.8	7.15	1.92	1.08	0.71
Mercury	0.0010	0.0090	0.0016	0.0016	8.61	1.54	1.57
Nickel	0.229	0.167	0.226	0.166	0.72	0.98	0.72
Selenium	0.104	0.179	0.085	0.124	1.72	0.82	1.19
Zinc	7.90	0.385	11.1	7.07	0.04	1.41	0.89
Calcium	520.	298.	851.	643.	0.57	1.64	1.24
Magnesium	86.9	234.	118.3	113.	2.70	1.36	1.31
Potassium	326.	337.	450.	350.	1.03	1.38	1.08
Sodium	377.	563.	584.	497.	1.49	1.55	1.32
Arsenic	0.085	0.062	0.057	0.063	0.73	0.66	0.74
Boron	2.38	3.21	4.24	9.88	1.34	1.77	4.14
Chloride	567.	754.	658.	638.	1.33	1.16	1.13
Fluoride	0.156	1.41	0.236	0.479	9.07	1.50	3.06
COD	18385.	5168.	21566.	12158.	0.28	1.17	0.66
BOD	11922.	3290.	15230.	11263.	0.28	1.28	0.94
BOD/COD	0.65	0.64	0.71	0.93	-	-	-
COD/TOC	3.06	3.05	3.42	2.70	-	-	-
TOC	6004.	1693.	6301.	4502.	0.28	1.05	0.75
Alkalinity	2642.	3515.	2914.	2524.	1.33	1.10	0.96
pH	5.31	6.62	5.18	5.88	1.25	0.97	1.11
Vol. Acids	1281.	437.	2915.	345.	0.34	2.28	0.27
TK Nitrogen	542.	379.	505.	401.	0.70	0.93	0.74
Phosphate	22.6	4.72	21.8	11.0	0.21	0.96	0.49
Volume (L)	143.	159.	189.	260.	1.12	1.32	1.82

N = No data or all samples below detection limits.

TABLE 41. AVERAGE CONCENTRATIONS AND VALUES FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW	MSW + GES			MSW+GES/MSW-Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	1.70	0.793	0.868	1.06	0.46	0.50	0.62
Beryllium	0.014	0.018	0.015	0.013	1.21	1.04	0.89
Cadmium	0.0041	0.0030	0.0046	0.0022	0.72	1.14	0.53
Chromium	0.100	0.078	0.118	0.069	0.77	1.17	0.69
Copper	0.012	0.009	0.014	0.027	0.78	1.23	2.30
Iron	396.	149.	356.	205.	0.38	0.90	0.52
Lead	0.016	0.006	0.019	0.009	0.40	1.18	0.59
Manganese	11.9	3.92	10.32	6.48	0.33	0.86	0.54
Mercury	0.0029	0.0021	0.0016	0.0012	0.73	0.55	0.43
Nickel	0.236	0.096	0.224	0.146	0.40	0.94	0.61
Selenium	0.071	0.069	0.090	0.194	0.97	1.27	2.73
Zinc	8.24	0.422	4.94	7.85	0.05	0.60	0.95
Calcium	618.	309.	825.	561.	0.50	1.34	0.91
Magnesium	105.	249.	110.	108.	2.36	1.05	1.03
Potassium	395.	349.	404.	348.	0.88	1.02	0.88
Sodium	535.	573.	476.	410.	1.07	0.89	0.77
Arsenic	0.045	0.061	0.043	0.080	1.35	0.94	1.77
Boron	2.82	4.13	3.88	9.40	1.46	1.37	3.33
Chloride	672.	754.	630.	531.	1.12	0.94	0.79
Fluoride	0.347	1.60	0.556	0.561	4.61	1.60	1.61
COD	23216.	7567.	21415.	11107.	0.33	0.92	0.48
BOD	12183.	7304.	15920.	8724.	0.60	1.31	0.72
BOD/COD	0.52	0.97	0.74	0.79	-	-	-
COD/TOC	3.25	3.18	3.30	2.67	-	-	-
TOC	7145.	2378.	6486.	4158.	0.33	0.91	0.58
Alkalinity	2555.	3221.	3089.	2441.	1.26	1.21	0.96
pH	5.34	6.49	5.22	6.05	1.21	0.98	1.13
Vol. Acids	1709.	332.	2195.	628.	0.19	1.28	0.37
TK Nitrogen	633.	418.	519.	439.	0.66	0.82	0.69
Phosphate	3.14	3.32	11.87	4.65	1.06	3.78	1.48
Volume (L)	143.	159.	189.	260.	1.12	1.32	1.82

TABLE 42. HIGHEST CONCENTRATIONS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR ABOVE-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW Only	MSW + GES			GES+MSW/MSW Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	2.00	3.18	5.30	3.83	1.59	2.65	1.91
Beryllium	N*	N	0.020	0.013	N	N	N
Cadmium	0.0219	0.287	0.0225	0.0230	13.1	1.02	1.05
Chromium	0.338	0.338	0.485	0.258	1.00	1.43	0.76
Copper	0.030	0.020	0.037	0.025	0.66	1.23	0.83
Iron	713.	355.	575.	327.	0.50	0.81	0.46
Lead	0.158	0.047	0.173	0.035	0.30	1.09	0.22
Manganese	18.6	217.0	27.0	15.3	11.6	1.45	0.82
Mercury	0.0023	0.0378	0.0045	0.0033	16.4	1.95	1.43
Nickel	0.483	1.03	0.713	0.485	2.14	1.47	1.00
Selenium	0.160	0.265	0.163	0.163	1.65	1.01	1.01
Zinc	21.7	1.17	42.0	19.4	0.05	1.93	0.89
Calcium	1117.	1230.	1470.	1145.	1.10	1.32	1.02
Magnesium	177.	417.	335.	215.	2.35	1.88	1.21
Potassium	615.	767.	1215.	822.	1.25	1.97	1.34
Sodium	942.	1412.	1632.	1070.	1.50	1.73	1.14
Arsenic	0.280	0.102	0.125	0.122	0.36	0.44	0.43
Boron	8.09	15.2	15.7	19.9	1.87	1.94	2.46
Chloride	1063.	1982.	1848.	1209.	1.86	1.74	1.14
Fluoride	0.349	2.30	0.581	1.17	6.59	1.66	3.36
COD	32600.	33300.	46400.	30400.	1.02	1.42	0.93
BOD	25000.	2000.	82000.	26000.	0.80	3.28	1.04
TOC	12000.	10700.	18500.	1500.	0.89	1.54	1.25
Alkalinity	8000.	7050.	9000.	3625.	0.88	1.13	0.45
pH	6.20	7.35	5.80	7.90	1.19	0.94	1.27
Vol. Acids	3715.	1840.	11200.	906.	0.50	3.01	0.24
TK Nitrogen	881.	1020.	1550.	1400.	1.16	1.76	1.59
Phosphate	31.40	12.80	28.40	25.40	0.41	0.90	0.81

* N = No data or all values below detection limits.

TABLE 43. HIGHEST CONCENTRATIONS FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR BELOW-SOIL SAMPLES

	Concentration (mg/l)				Ratios		
	MSW	MSW + GES			GES+MSW/MSW Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	14.9	3.55	6.20	3.90	0.23	0.41	0.26
Beryllium	0.017	0.025	0.020	0.013	1.42	1.14	0.74
Cadmium	0.0185	0.0131	0.0290	0.0114	0.70	1.56	0.61
Chromium	0.361	0.721	0.531	0.448	1.99	1.47	1.24
Copper	0.040	0.028	0.045	0.148	0.70	1.12	3.70
Iron	1470.	715.	558.	550.	0.49	0.38	0.37
Lead	0.052	0.020	0.093	0.020	0.38	1.78	0.38
Manganese	23.1	16.7	27.5	27.2	0.72	1.19	1.17
Mercury	0.0055	0.0073	0.0035	0.0023	1.32	0.63	0.41
Nickel	0.468	0.375	0.673	0.698	0.80	1.43	1.49
Selenium	0.125	0.103	0.145	0.220	0.82	1.16	1.76
Zinc	19.0	0.910	11.1	19.3	0.04	0.58	1.01
Calcium	1372.	1127.	1535.	1375.	0.82	1.12	1.00
Magnesium	222.	482.	320.	300.	2.17	1.44	1.35
Potassium	787.	707.	1165.	1235.	0.90	1.48	1.57
Sodium	1142.	1847.	1705.	1300.	1.62	1.49	1.14
Arsenic	0.140	0.180	0.137	0.232	1.28	0.98	1.66
Boron	8.74	17.4	13.6	23.7	1.99	1.55	2.71
Chloride	1322.	2059.	1943.	1234.	1.56	1.47	0.93
Fluoride	0.775	2.75	1.58	1.65	3.54	2.04	2.12
COD	66800.	34000.	46500.	42750.	0.51	0.70	0.64
BOD	32000.	58000.	79000.	42900.	1.81	2.47	1.34
TOC	13500.	11200.	15000.	16000.	0.83	1.11	1.19
Alkalinity	5200.	5925.	9000.	3525.	1.14	1.73	0.68
pH	6.00	7.40	5.80	7.50	1.23	0.97	1.25
Vol. Acids	9740.	2050.	7200.	3200.	0.21	0.74	0.33
TK Nitrogen	966.	947.	1560.	2500.	0.98	1.61	2.59
Phosphate	4.90	7.10	19.6	25.4	1.45	4.00	5.18

TABLE 44. TOTAL MASS LEACHED PER KG DRY MSW FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR ABOVE-SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW	MSW + GES			GES+MSW/MSW Only		
	Only	Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	0.915	1.83	1.21	1.45	2.00	1.32	1.58
Beryllium	N*	N	0.001	0.003	-	-	-
Cadmium	0.0072	0.0080	0.0071	0.0141	1.11	0.98	1.97
Chromium	0.242	0.129	0.360	0.257	0.53	1.48	1.06
Copper	0.015	0.018	0.025	0.021	1.16	1.65	1.39
Iron	779.	153.	873.	595.	0.20	1.12	0.76
Lead	0.054	0.034	0.053	0.047	0.63	0.98	0.87
Manganese	21.8	30.2	27.9	25.2	1.38	1.28	1.15
Mercury	0.0005	0.0032	0.0014	0.0020	6.43	2.93	3.97
Nickel	0.505	0.309	0.585	0.646	0.61	1.15	1.27
Selenium	0.057	0.043	0.055	0.049	0.76	0.97	0.86
Zinc	14.7	1.00	24.3	20.5	0.06	1.65	1.39
Calcium	1117.	612.	2400.	2327.	0.55	2.15	2.08
Magnesium	189.	527.	312.	403.	2.78	1.65	2.13
Potassium	723.	752.	1263.	1330.	1.04	1.75	1.84
Sodium	838.	1280.	1579.	1765.	1.53	1.88	2.11
Arsenic	0.102	0.032	0.086	0.037	0.31	0.84	0.36
Boron	4.94	6.32	10.2	29.3	1.27	2.07	5.93
Chloride	995.	1389.	1605.	1764.	1.39	1.61	1.77
Fluoride	0.191	1.94	0.386	1.18	10.1	2.02	6.18
COD	38405.	9420.	63575.	42285.	0.25	1.66	1.10
BOD	25203.	5545.	34325.	32460.	0.22	1.36	1.29
BOD/COD	0.66	0.59	0.54	0.77	-	-	-
COD/TOC	3.67	4.11	4.32	3.42	-	-	-
TOC	10471.	2293.	14723.	12382.	0.22	1.41	1.18
Alkalinity	5849.	7492.	7967.	7597.	1.28	1.36	1.30
Vol. Acids	2387.	775.	6439.	834.	0.32	2.70	0.35
TK Nitrogen	1191.	891.	1450.	1300.	0.75	1.22	1.09
Phosphate	50.1	8.68	57.2	34.9	0.17	1.14	0.70

* N = No data or all data below detection limits.

TABLE 45. TOTAL MASS LEACHED PER KG DRY MSW FOR PARAMETERS FROM MSW TEST CELLS CONTAINING TREATED AND UNTREATED GLASS-ELECTRONICS SLUDGE (900) FOR BELOW-SOIL SAMPLES

	Mass (mg/kg dry MSW)				Ratios		
	MSW Only	MSW + GES			GES+MSW/MSW Only		
		Untr.	Proc. A	Proc. B	Untr.	Proc. A	Proc. B
Aluminum	3.03	1.11	1.55	3.25	0.36	0.51	1.07
Beryllium	0.007	0.007	0.011	0.002	1.03	1.60	0.25
Cadmium	0.0073	0.0042	0.0081	0.0070	0.57	1.11	0.96
Chromium	0.196	0.129	0.317	0.203	0.66	1.62	1.03
Copper	0.018	0.017	0.023	0.073	0.93	1.31	4.14
Iron	1007.	233.	986.	694.	0.23	0.98	0.69
Lead	0.022	0.010	0.037	0.032	0.43	1.66	1.48
Manganese	25.8	6.01	28.2	24.4	0.23	1.09	0.94
Mercury	0.0018	0.0007	0.0015	0.0010	0.38	0.86	0.55
Nickel	0.522	0.170	0.601	0.543	0.32	1.15	1.04
Selenium	0.031	0.028	0.050	0.079	0.92	1.62	2.57
Zinc	15.1	0.106	12.0	15.8	0.01	0.79	1.05
Calcium	1338.	573.	2332.	2284.	0.43	1.74	1.71
Magnesium	230.	530.	314.	429.	2.30	1.37	1.86
Potassium	876.	744.	1193.	1379.	0.85	1.36	1.57
Sodium	1178.	1128.	1346.	1618.	0.96	1.14	1.37
Arsenic	0.046	0.077	0.118	0.119	1.67	2.58	2.59
Boron	5.83	7.37	10.2	33.0	1.26	1.75	5.65
Chloride	1175.	1365.	1446.	1607.	1.16	1.23	1.37
Fluoride	0.471	2.30	0.881	1.41	4.89	1.86	3.00
COD	50151.	14508.	62158.	39992.	0.29	1.24	0.80
BOD	26581.	9139.	36966.	33216.	0.34	1.39	1.25
BOD/COD	0.53	0.63	0.59	0.83	-	-	-
COD/TOC	4.12	4.14	4.12	3.38	-	-	-
TOC	12164.	3500.	15100.	11833.	0.29	1.24	0.97
Alkalinity	5328.	6304.	8355.	8600.	1.18	1.57	1.61
Vol. Acids	3931.	639.	5975.	3605.	0.16	1.52	0.92
TK Nitrogen	1401.	908.	1477.	1364.	0.65	1.05	0.97
Phosphate	5.45	5.68	26.19	8.53	1.04	4.80	1.56

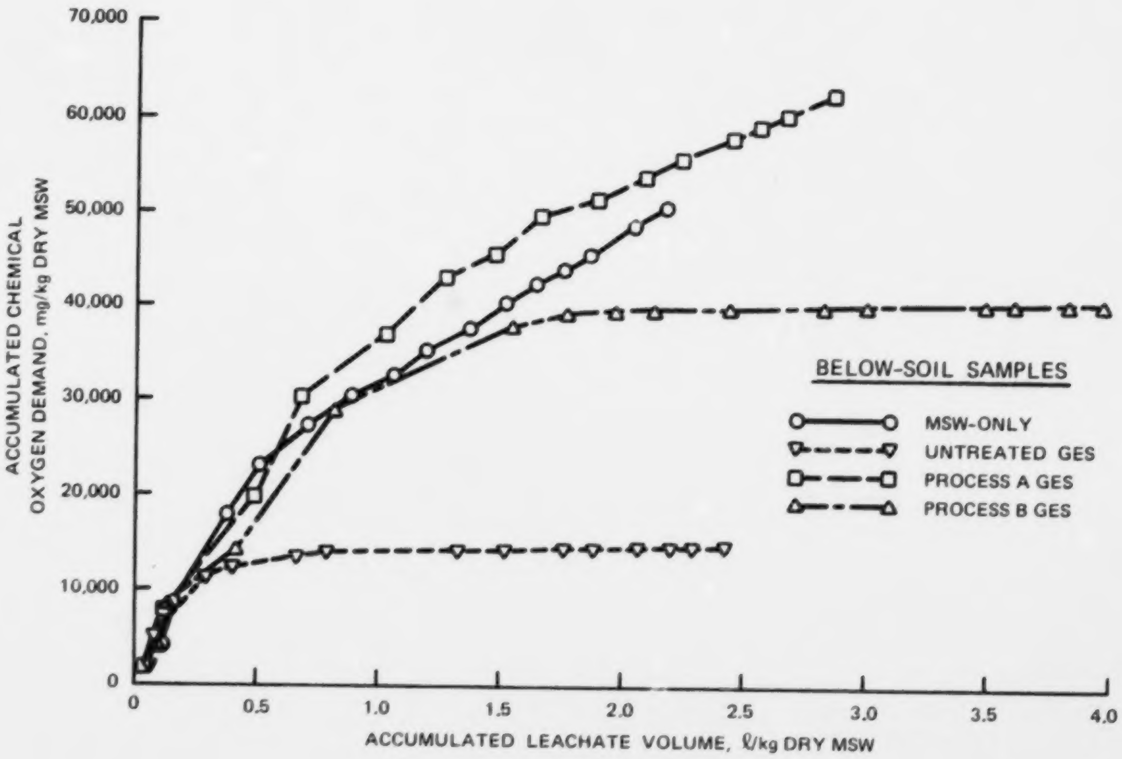

Figure 45. Plot of chemical oxygen demand by volume for below-soil, GES leachates.

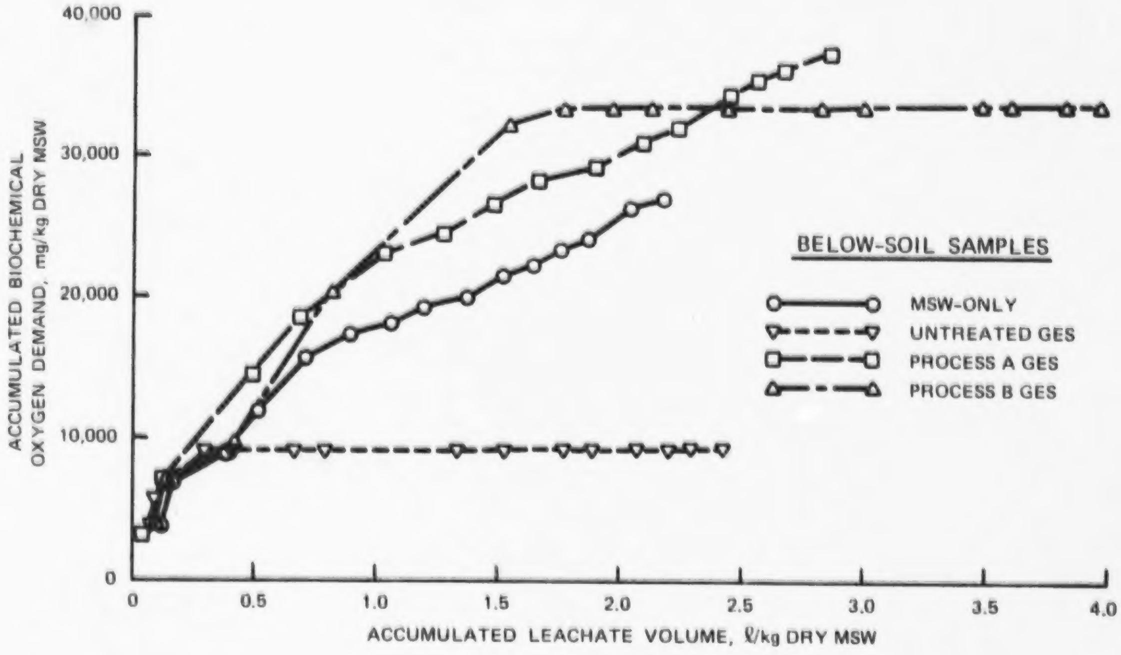

Figure 46. Plot of biochemical oxygen demand by volume for below-soil, GES leachates.

leachates. This lower biological activity is also the most probable cause of the lower moisture retention in the untreated GES test cell.

The most dramatic effects of the untreated GES on the composition of the leachates are in elevated levels of cadmium, mercury and fluoride. These constituents are at 3.5 to 10 times their levels in the MSW-only leachates. Since cadmium and mercury levels in the GES dry solids are very low (around 5 mg/kg), their elevated levels in the leachates must reflect the effects of the waste on the leaching of the MSW; levels of both are increased to concentrations which are above the drinking water standards in the untreated GES-MSW leachates. The source of added fluoride is probably the appreciable levels in the GES.

Of the materials making up over 1% dry wt of the GES, aluminum (175%), magnesium (270%, Fig. 47), and chloride (133%, Fig. 48) are elevated over the MSW-only leachate levels. These higher levels probably represent additions to the leachates from the GES. Of this group of elements, only calcium (Fig. 49) is found at lower levels in the untreated GES-MSW leachates probably due to their more basic pH values.

Of those constituents present in the dry GES solids at levels below 10,000 and above 200 mg/kg dry solids, only sodium (149%, Fig. 50) occurs at higher concentrations in the above soil samples in the untreated GES MSW leachates while copper and potassium are similar in concentrations in the leachates with or without GES. All of the other constituents in this group are leached at lower rates in the untreated GES-MSW leachates than in the MSW-only leachates-- chromium (57%), iron (27%), lead (45%), nickel (72%) and zinc (4%). These lower levels again probably reflect the higher pH and lower microbial activity of the untreated GES-MSW leachates.

Below-soil leachate samples show quite similar patterns of leachate concentrations with only a few exceptions. Constituents removed from the leachates in appreciable quantities (total masses leached) in the soil layer are lead (71% removed), manganese (80%) mercury (78%), nickel (45%) and zinc (89%). Both COD and BOD levels were increased by passage through the soil layer, 146% and 222% respectively, resulting in a COD/BOD ratio of 97% meaning that almost all of the oxygen demand is now amenable to microbial action. Nitrogen and phosphate levels were not strongly affected by the soil-layer, indicating a low level of microbial activity even in the soil layer.

Treated GES-MSW Leachate Characteristics

Solidification/stabilization again is seen to moderate but not alleviate the effects of the GES on the MSW leachates. The pH values and COD (Fig. 41), BOD (Fig. 42), TOC and nutrient levels are more similar to the MSW-only leachates than the untreated GES-MSW leachates indicating microbial activity more typical of MSW alone. The greatly elevated levels of cadmium, mercury and fluoride seen for the untreated GES-MSW leachates have largely been moderated by the treatment process so that their levels, while still slightly higher, are much more nearly typical of the MSW-only leachates.

The increased volume of leachate produced from the test cells containing treated GES (118% for Process A and 162% for Process B) effects the leaching results. Constituents which have limited solubility in the leachates would be

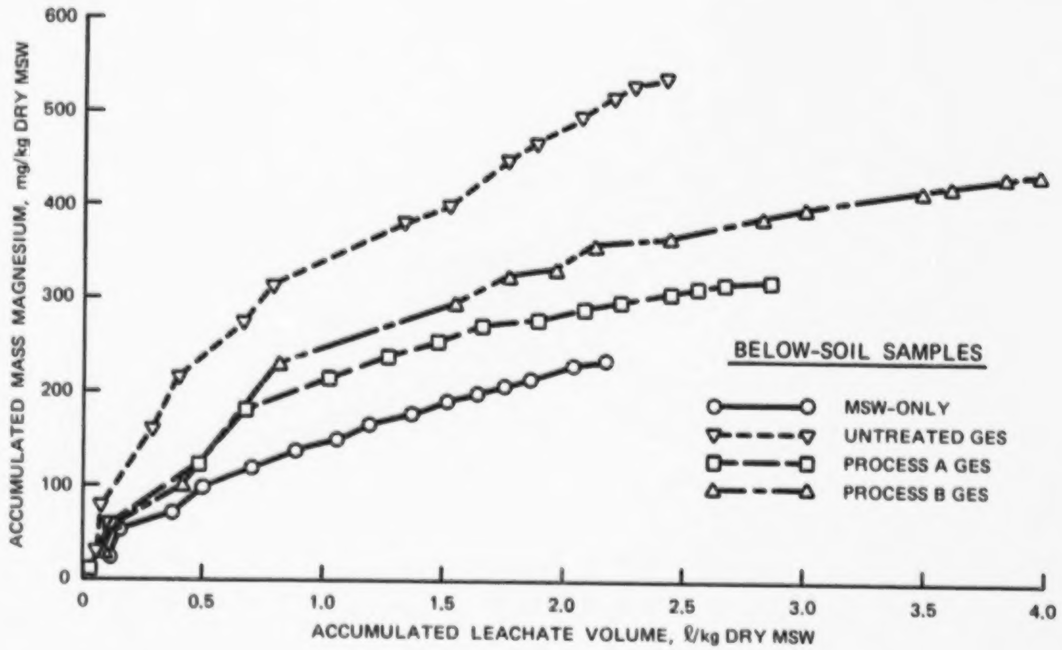

Figure 47. Plot of magnesium by volume for below-soil, GES leachates.

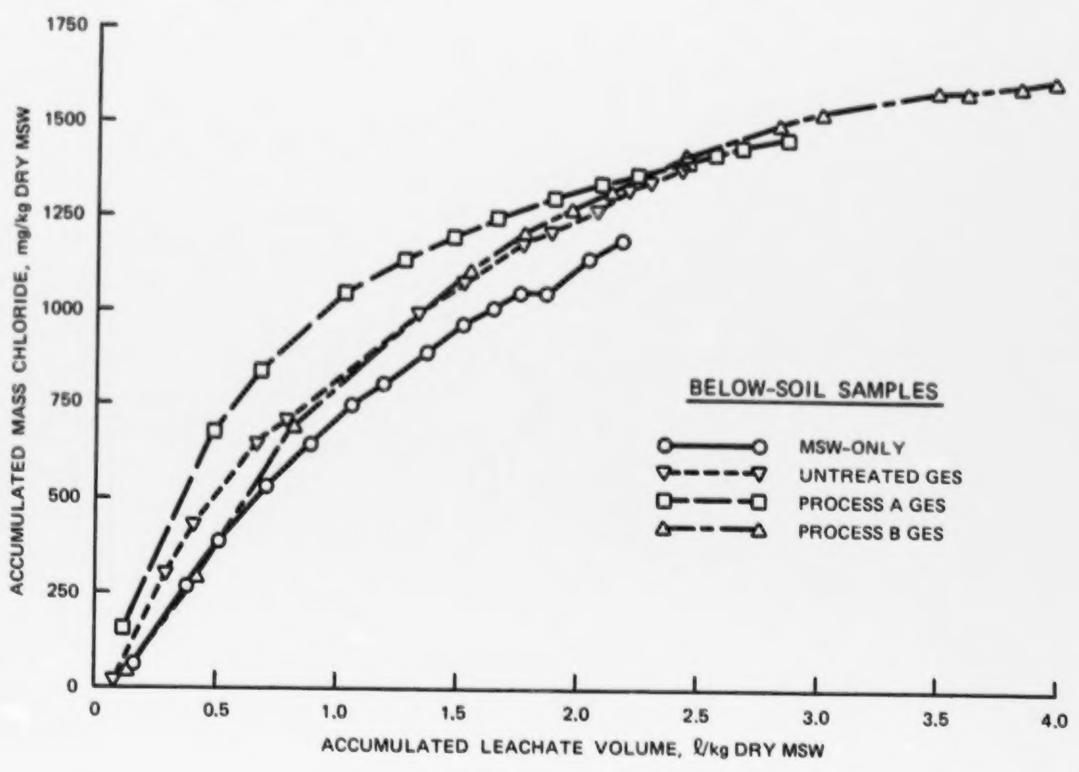

Figure 48. Plot of chloride by volume for below-soil, GES leachates.

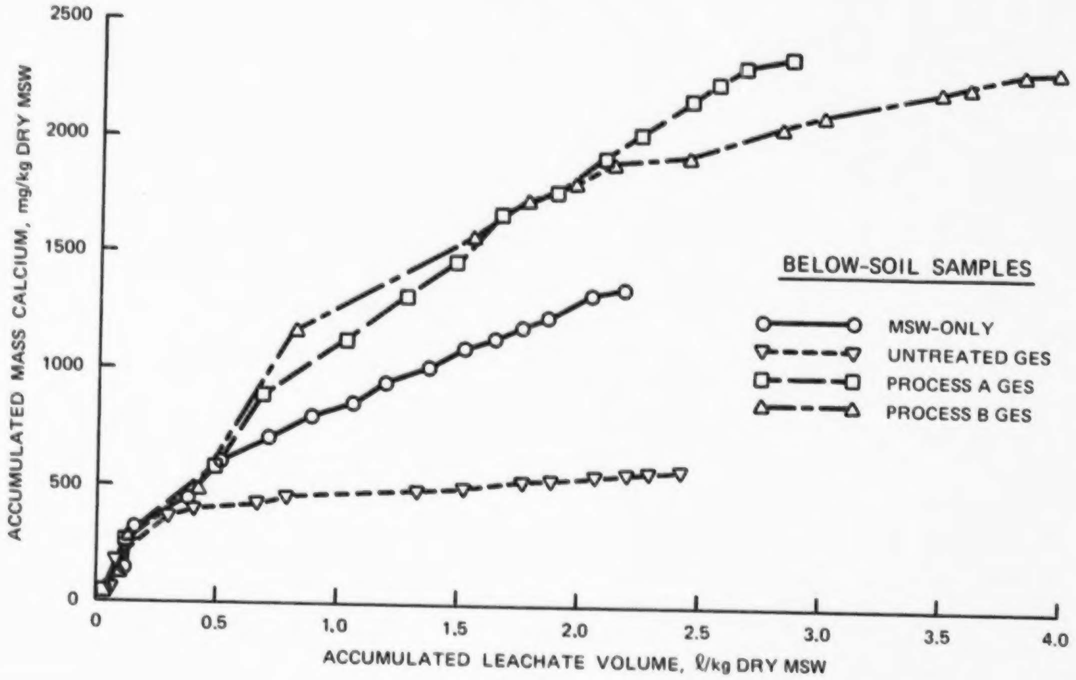

Figure 49. Plot of calcium by volume for below-soil, GES leachates.

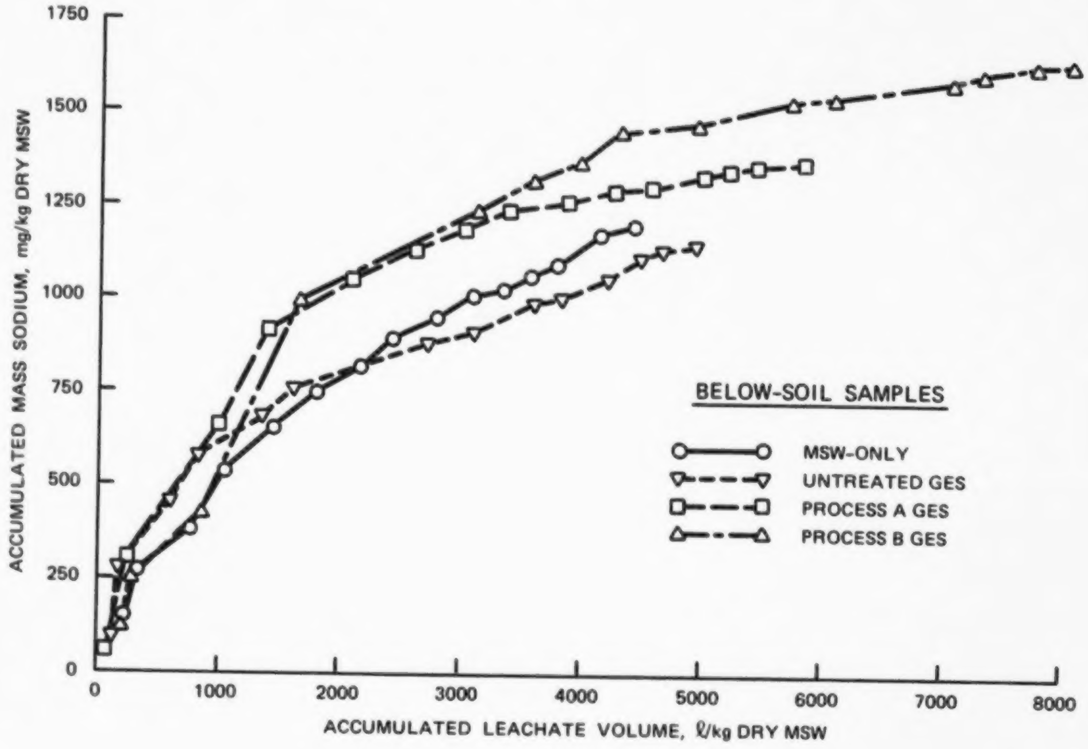

Figure 50. Plot of sodium by volume for below-soil, GES leachates.

expected to be leached at similar concentrations, but in greater amounts in the larger volumes. Very soluble materials may be leached in similar or lower concentrations, but in similar total amounts at the end of the experiment, depending upon the amount available to be leached more than the amount of leachate produced. The results are first discussed on the basis of overall average concentration in the leachates, after which any discrepancies due to the higher leachate volumes will be addressed. In general, no dramatic changes in leachate characteristics could be attributed to the different leachate volumes from the different test cells.

Of the major constituents (over 1%), both treatment processes moderated the higher levels of magnesium (Fig. 47) but had very little effect on the chloride concentration (Fig. 48) from the GES containing test cells. Calcium (Fig. 49), however, which was leached at lower rates from the untreated GES-MSW test cell, was leached at higher rates from both treated GES-MSW cells due to a combination of more acidic leachates and higher calcium loading in the GES. Aluminum was leached at similar or higher rates from the treated GES cells than from the untreated GES-MSW test cell (160% and 280% higher than from the MSW-only, control cell for Processes A and B respectively).

For the GES constituents found in lower concentration, (200 to 10,000 mg/kg dry solids) treatment of the added GES had very little effect on the higher rate of loss of sodium (Fig. 50) and potassium average values being within 10% of the untreated GES test cell for both treatment processes (143 and 123% higher than the MSW-only test cell leachates on the average). Copper showed similar results (117% of control average concentrations). Of the metals which were leached at lower concentrations in the untreated GES-MSW leachates than in the MSW-only leachates--chromium, iron, lead, nickel and zinc--all were leached at concentrations more typical of MSW-only leachates. Iron, which was lost in very low concentrations from the untreated-GES test cell (27% of MSW-only) probably due to low biological activity (iron-reducing bacteria), was lost at 98% and 57% of the MSW-only levels from Process A and B treated GES containing test cells respectively. This supports the contention of higher biological activities in the treated-GES containing test cells. Zinc, which was almost absent from the untreated GES-MSW leachates (4% of MSW-only), was lost at 140% and 90% of the MSW-only rate from Process A and B test cells.

Data for total masses leached follow the same general patterns as those for concentration except for larger total amounts of materials which are solubility-limited in the leachates, especially from test cell 13 which contained the GES treated by process B which produced 62% more leachate than the untreated-GES containing test cell. Total masses leached from this test cell (13) are typically higher while the concentrations of the constituents are generally lower. For instance, calcium (Fig. 49) and chromium have 124% and 61% of the MSW-only leachate concentrations in Process B treated GES leachates, but are leached in greater relative total masses, 208% and 106% respectively, both around 60% greater. And as seen in Figure 48 for chloride, the leaching rates per unit volume of leachate produced are nearly identical for all GES containing test cells, but the additional leachate produced from Process B-treated GES containing test cell brings about a higher total chloride mass leached from this cell. The higher amounts of leachate from the treated GES test cells did not seem to invalidate the results from these cells.

STATISTICAL ANALYSES AND SUMMARY

In all cases, the addition of either treated or untreated IW to the MSW-containing test cells had significant effects on the levels of at least some of the constituents for which analyses were made. Paired comparisons between parameter values for different test cells were made using a modified T Test (35). For all comparisons, the differences in parameter values for each sampling time were determined and these differences tested as to whether the mean difference was significantly different from zero at the 95% confidence level. This procedure increased the power of the comparisons over using the overall treatment means while at the same time subtracting out variation due to consistent differences between sampling times. This methodology assumes that leaching pattern for each parameter is the same from all test cells. This is generally believed to be the case; however, difference in leaching patterns between paired test cells would be expected to cause loss of significance (type 1 error) rather than an overestimation of significant differences (type 2 error).

Comparisons Between IW-MSW and MSW-only Leachates

Paired T tests between leachate levels of all parameters from test cells containing treated or untreated IW are summarized in Table 46. Significant differences are found in 42% of the cases (103 out of 243 possible), 30% (74 cases) having higher levels in IW+MSW leachates and 12% (29 cases) having lower levels. No significant differences are seen for only two of the constituents--lead and total volatile acids, and only one significant difference is seen for copper, mercury, arsenic and total Kjeldahl nitrogen. Leachates from the EPW and CPB containing test cells have consistently higher conductivities than the MSW-only leachates.

In general, the untreated EPW-MSW leachates had significantly higher levels of the largest number of metals (first 11 rows in the table) with 4--aluminum, chromium, copper, and nickel --significantly higher in leachates from MSW plus untreated EPW, while significantly lower levels of iron, manganese and zinc were found. The CPB and GES were each higher in only one of these metals, cadmium and aluminum respectively; both were lower in iron and the GES also lower in chromium. Treatment Process A was effective in holding all of these to insignificant differences except for nickel in the EPW and CPB containing test cells. Process B treated wastes varied widely having three metals at higher levels in the EPW--cadmium, manganese and nickel --and four at significantly lower levels in the GES leachates--chromium, iron, lead and nickel.

Of the major cations present, magnesium and sodium were significantly higher in all treated and untreated IW leachates except for both treated versions of the GES. Calcium was lower or not significantly different in all untreated IW leachates and higher in all treated IW leachates except process B treated GES. Potassium was also generally found at higher levels except in the GES-MSW leachates.

Chloride and boron are found at higher average levels in the majority of the leachates from treated or untreated IW containing test cells. COD and BOD are significantly lower only in the GES containing test cells which had the

TABLE 46. SUMMARY OF STATISTICAL ANALYSIS COMPARING LEACHATE SAMPLES FROM TEST CELLS CONTAINING IW+MSW WITH THOSE CONTAINING MSW-ONLY

	Test Cells Containing Treated and Untreated IW and MSW								
	MSW + EPW			MSW + CPB			MSW + GES		
Parameter	Untr.	A	B*	Untr.	A	B*	Untr.	A	B
Aluminum	Hi	-	-	-	-	-	Hi	-	-
Cadmium	-	-	Hi	Hi	-	-	-	-	-
Chromium	Hi	-	-	-	-	Hi	Low	-	Low
Copper	Hi	-	-	-	-	-	-	-	-
Iron	Low	-	-	Low	-	-	Low	-	Low
Lead	-	-	-	-	-	-	-	-	-
Manganese	Low	-	Hi	-	-	-	-	-	Low
Mercury	-	-	-	-	-	Low	-	-	-
Nickel	Hi	Hi	Hi	-	Hi	-	-	-	Low
Selenium	-	-	-	-	-	-	-	-	-
Zinc	Low	Low	Hi	-	Hi	-	Low	Hi	-
Calcium	-	Hi	Hi	-	Hi	Hi	Low	Hi	-
Magnesium	Hi	Hi	Hi	Hi	Hi	Hi	Hi	-	-
Potassium	-	Hi	Hi	Hi	-	Hi	-	-	-
Sodium	Hi	Hi	Hi	Hi	Hi	Hi	Hi	-	-
Arsenic	-	-	-	-	-	Hi	-	-	-
Boron	Hi	Hi	Hi	Hi	Hi	Hi	-	Hi	Hi
Chloride	Hi	Hi	Hi	Hi	Hi	Hi	Hi	-	-
Fluoride	Hi	-	-	-	-	-	Hi	-	-
COD	-	-	-	-	-	-	Low	-	Low
BOD	Low	-	-	-	-	-	Low	-	Low
TOC	Low	Hi	Hi	-	Hi	-	Low	-	Hi
Alkalinity	Hi	-	Hi	Hi	-	Hi	Hi	-	-
Vol. Acids	-	-	-	-	-	-	-	-	-
TK Nitrogen	-	-	-	-	-	-	Low	-	-
Phosphate	Low	Low	Hi	Low	Low	Low	Low	-	Low
Conductivity	Hi	Hi	Hi	Hi	Hi	Hi	-	-	Hi

NOTE: Hi = Significantly higher average value in cell containing IW, Low = significantly lower; '-' = no significant difference. Paired T tests by sampling time at 95% confidence level (35).

* Comparison made between below-soil leachate samples, all others above-soil.

greatest effect upon the biological activity in the cell. Phosphate is significantly lower in all leachates from test cells containing IW.

Effects of Waste Treatment on Leachate Parameters

Statistical analyses comparing characteristics of leachates from treated IW test cells with untreated IW test cells are shown in Table 47. Treatment of the IW has mixed effects upon the levels of metals in the leachates with several of them being higher in the leachates from the treated IW than from the untreated IW test cells--iron and zinc especially higher in the treated IW leachates due probably to their more acidic pH's. Manganese and chromium also were higher in two of the treated leachates, manganese in both treated EPW leachates. Cadmium was significantly lower in leachates from both treated CPB test cells. Neither treatment process consistently lowered the metal concentrations in the IW-MSW leachates.

Of the major cations, calcium was not significantly different in the treated EPW and CPB leachates but was higher in leachates from both treated GES test cells. Magnesium was consistently lower in the treated IW's. Sodium was held to lower concentrations in one half of the treated IW test cell leachates (two from EPW), while potassium was found at higher concentration in the same three.

Chloride was held to significantly lower concentrations in the treated GES and CPB leachates. In general, the treated IW leachates had higher levels of the parameters believed to arise from biological activity in the MSW--COD, BOD, TOC, and total phosphate. Also 4 out of the 6 had lower alkalinity. Conductivities were generally not significantly different except for both treated CPB test cells which had lower conductivities.

The last 3 columns in the table compare leachates from test cells containing process A treated wastes to those with process B treated wastes. Both treatment processes had about equal effects on leachates from the treated EPW test cells for below-soil samples--process A test cells having leachates higher in iron, alkalinity and overall conductivity but lower levels of manganese, zinc, and phosphate. For the CPB leachates, process A treated wastes produced lower chromium, manganese, magnesium, arsenic, boron and TOC but higher alkalinity, conductivity and zinc. Process A was less successful than process B leachates from the GES-MSW test cells being higher in 13 of the 27 parameters determined and lower in only 1 (boron).

TABLE 47. SUMMARY OF STATISTICAL ANALYSIS COMPARING LEACHATE SAMPLES FROM TEST CELLS CONTAINING PROCESS A AND B TREATED WASTES AND THOSE CONTAINING UNTREATED IW AND TO EACH OTHER

	Process A IW to Untreated IW			Process B IW to Untreated IW			Process A IW to Process B IW		
Parameter	EPW	CPB	GES	EPW*	CPB*	GES	EPW*	CPB*	GES
Aluminum	Low	-	Hi	-	-	-	-	-	-
Cadmium	-	Low	-	-	Low	-	-	-	-
Chromium	Low	-	Hi	-	Hi	-	-	Low	Hi
Copper	-	-	-	-	-	-	-	-	-
Iron	Hi	Hi	Hi	-	Hi	Hi	Hi	-	Hi
Lead	-	-	-	-	-	-	-	-	-
Manganese	Hi	-	-	Hi	-	-	Low	Low	Hi
Mercury	-	-	-	-	-	-	-	-	-
Nickel	-	-	-	-	-	-	-	-	Hi
Selenium	-	-	-	-	-	-	-	-	-
Zinc	Hi	-	Hi	Hi	-	Hi	Low	Hi	Hi
Calcium	-	-	Hi	-	-	Hi	-	-	Hi
Magnesium	Low	Low	Low	Low	-	Low	-	Low	-
Potassium	Hi	-	-	Hi	Hi	-	-	-	Hi
Sodium	Low	-	-	Low	Low	-	-	Hi	-
Arsenic	-	-	-	-	-	-	-	Low	-
Boron	Low	-	-	Low	Hi	Hi	-	Low	Low
Chloride	-	Low	Low	-	Low	Low	-	-	-
Fluoride	Low	-	-	-	-	Low	-	-	-
COD	Hi	-	Hi	Hi	-	-	-	-	Hi
BOD	Hi	-	Hi	-	-	-	-	-	-
TOC	Hi	Hi	Hi	Hi	Hi	Hi	-	Low	Hi
Alkalinity	Low	Low	-	Low	Low	Hi	Hi	-	-
Vol. Acids	-	-	Hi	-	-	-	-	-	Hi
TK Nitrogen	-	-	-	-	-	-	-	-	Hi
Phosphate	Hi	Hi	Hi	Hi	Hi	Hi	Low	-	Hi
Conductivity	Hi	Low	-	-	Low	-	Hi	Hi	Hi

* Comparison between below-soil samples since complete set of above-soil samples were not available for these test cells.

NOTE: Hi = Significantly higher average value in first mentioned test cell; Low = significantly lower; '-' = no significant difference. Paired T tests by sampling time at 95% confidence level.

SECTION 6
DISCUSSION

The MSW contained in a typical municipal landfill is biologically and chemically degraded under high moisture and anaerobic conditions. Thus this process can be considered as a special case of anaerobic digestors used in other waste treatment systems. Microbiological activities in landfilled MSW is expected to respond to environmental and compositional conditions in an manor analogous to common waste digestors so that this body of knowledge can be applied, with suitable caution, to landfills and landfill simulators (7, 13, 15, 25).

LEACHATES FROM TEST CELLS CONTAINING MSW-ONLY

Leachate composition and leaching patterns for test cells containing MSW-only seen in this study parallel those reported in the literature for both laboratory leaching studies and field collections (7, 11, 15, 25). Concentrations of parameters in the leachates from the MSW-only test cells used in this study are shown in Table 48 for the first 6 months of sampling (7 samples) and the fourth year of sampling (5 samples); also calculated is the concentration during year 4 as a percentage of the level in the first 6 months. The majority of parameters have dropped to 10 to 30% of the original values. However, several of the heavy metals (cadmium, copper and manganese), organic and demand parameters (COD, alkalinity, total volatile acids), nutrients and conductivity remain typically from 30 to 60% of their original levels. Only iron and lead have higher, almost double, concentrations at the end of the experiment. The most soluble substances, sodium and chloride are 18 and 23% of their original values respectively. Conductivities average about half their original values.

Chian and DeWalle (31) have proposed the relationships given in Table 49 for young, medium and old landfill leachates from their laboratory and field studies. The values for leachates in this study parallel those published in both range and trend, except for the ratio of COD/TOC in the 3-4 year old leachates. This increase in COD/TOC ratio is thought to be the result of lower volatile acids after this time. According to Chian and DeWalle, these leachates should be quite amenable to biological treatment and be good substrates for methane production even at the end of this study.

Considerable variations were found in leachate composition between MSW-only test cells and subsequent samples from the same test cell (see comparison between MSW-only test cells in tables 15 through 20.) This variability is typical of leachates from such heterogeneous materials as MSW (11, 25) and introduces an unknown dimension in the comparison of leachates from the test cells containing treated and untreated IW. Other sources of variation are temperature, pH, moisture, nutrients and MSW configuration (7, 24, 25, 26). No way around this problem is seen for codisposal studies other than the use of large quantities of well-mixed MSW such as those used in this study. The simplification of exposure of IW to MSW leachates alone as used by Houle (4) completely neglects any interaction between the IW and the MSW itself.

The major, consistent differences in comparing the large and small MSW-only test cells used in this study are confined largely to the amount of liquid

TABLE 48. COMPARISON OF AVERAGE COMPOSITION OF ALL ABOVE-SOIL, MSW-ONLY TEST CELL LEACHATES TAKEN IN FIRST SIX MONTHS OR FOURTH YEAR OF SAMPLING

Parameter	1st 6 Months	Fourth Year	% of 1st 6 Months
Aluminum	2.14	0.32	15
Beryllium	-	-	
Cadmium	0.008	0.003	37
Chromium	0.218	0.016	7.3
Copper	0.015	0.008	53.
Iron	285.	588	206.
Lead	0.024	0.043	180
Manganese	15.5	5.48	35
Mercury	0.0017	BDL	-
Nickel	0.400	0.073	18
Selenium	0.087	BDL	-
Zinc	17.5	1.77	10
Calcium	1030.	303.	29
Magnesium	166.	38.	23
Potassium	663.	119	18
Sodium	769.	140	18
Arsenic	1.03	0.06	5.6
Boron	8.44	0.78	9.2
Chloride	1120.	253.	23
Fluoride	0.549	0.090	16
COD	34050	12600.	37
BOD	23600	5230.	22
TOC	11300	3415.	30
Alkalinity	3060	2510.	82
pH*	5.23	5.44	104
Vol. Acids	1450.	1200	82
TK Nitrogen	928.	302	32
Total Phosphate	23.0	15.1	66
Conductivity	8200.	4210	51

* Arithmetic mean for comparison only.

TABLE 49. PROPOSED RELATIONSHIPS BETWEEN AGE OF LANDFILL AND ORGANIC AND DEMAND PARAMETERS OF THE LEACHATES COMPARED WITH THOSE FOUND IN THIS STUDY FOR MSW-ONLY LEACHATES

Age of Landfill	Chian and DeWalle (25)			This Study		
	COD	COD/TOC	BOD/COD	COD	COD/TOC	BOD/COD
Young (< 5 yr)	> 10,000	> 2.8	> 0.5	34050*	3.0	0.69
Medium (5-10 yr)	500-10,000	2.0-2.8	0.1-0.5	12600**	3.6	0.41
Old (> 10 yr)	< 500	< 2.0	< 0.1			

Note: COD in mg/l.
* 1st 6 months.
** 3.5 year old leachates from this study.

retained in the MSW (the "field capacity") and a more rapid decrease in leachate conductivities (ionic strength) in the smaller cells. Highly soluble constituents, such as potassium, sodium and chloride, were lost from both test cell sizes in direct proportion to the amount of MSW present. Other parameters such as boron, calcium, copper, iron, zinc and oxygen demand measurements were found in nearly equal concentrations in leachates from the different sizes of test cells, indicating that their loss rate was limited by their solubility or production rates; i.e., their leachate concentrations were largely independent of MSW volume or leachate addition rate.

EFFECTS OF ADDED IW ON MSW LEACHATE CHARACTERISTICS

pH, Organic Carbon, Nutrient and Demand Parameters

All three IWs included in this study produced measurable effects upon the quality of leachates produced by the MSW landfill simulation. The most dramatic of these effects were on leachate pH and oxygen demand parameters as summarized for all test cells in Table 49.

The pH has a profound effect upon the types and rates of chemical and biological activities which will occur in anaerobic digestors. The pH which is developed during any stage in the digestion or stabilization process is largely a function of the relationship between the volatile acids and alkalinity in the leachate and the carbon dioxide evolved. The optimum leachate pH for methanogenesis is generally reported to be between 6.8 and 7.2 although significant deterioration is not usually found between 6.6 and 7.4 (15, 25). The leachate pH's from all test cells containing untreated IW average about one pH unit more basic than those from the MSW-only cells, ranging from about 6.2 to 6.6. Effects of the high pHs are reflected in the uniformly higher alkalinities (averaging 50% higher) in the untreated IW leachates, and the lower total volatile acids (except in the CPB leachates), and the generally lower organic carbon content. These changes reflect significant differences in the chemical and biological activities which can produce marked differences in metal ion interactions and solubilities.

The added IW may have had beneficial effects upon the anaerobic stabilization of the MSW by increasing the pH to a range more conducive to rapid methanogenesis. This would account for the lower CODs and especially BODs (volatile acid portion) levels found in the leachates. The more acid conditions in the MSW-only and treated IW-MSW test cells may have inhibited the development of the methanogenic flora necessary for rapid decomposition of the organic acids produced by acid fermentation. Measurements of gas production from the MSW-only test cells bears this out as methane production had only begun to be developed in all 4 MSW-only test cells by the end of the study (day 1510), indicating low activity of methanogenic bacteria in these cells (19, 20).

An alternative explanation of the low oxygen demand and volatile acids in the leachates from test cells containing untreated IW suggests that the untreated IWs are in someway toxic or inhibitory to the bacterial flora so that acid hydrolysis activity itself is slowed. Chian and DeWalle (31) found that metal toxicity (probably induced by copper) occurred in their anaerobic, MSW leachate digestors at pHs below about 6.8. But as will be discussed, no appreciable concentrations which might account for such toxicity were seen in this experiment. At this time no definitive decision between these two explanations can be made in this study. Other codisposal studies using only untreated IWs have reported no effect of added IW on MSW decomposition rates (5, 9, 11).

In all cases, solidification of the IW before codisposal by either process generally masked the IW effects seen for the untreated IW. In fact, the leachates from test cells containing solidified IWs had COD, BOD and organic carbon levels higher than the MSW-only leachates and pH values typical of the MSW-only leachates. Only the test cell containing GES as treated by process B produced a decrease in these parameters (similar to the untreated IWs).

Major Cations and Chloride

The addition of EPW and GES to the MSW landfill simulators increased the major soluble species found in the leachates only slightly over the levels in the MSW-only test cell leachates (Table 50). Sodium, potassium, calcium, magnesium, manganese and chloride were typically found at average concentrations from 120 to 200% of those in the MSW-only leachates for both treated and untreated IW leachate samples (Table 51). The only exception is the very low levels of calcium lost from the untreated GES test cell.

The large amounts of soluble salts in the CPB which are clearly evident in the leachates by their high conductivities are represented almost entirely as very high concentrations of sodium and chloride (50 and 43 times their average concentrations in the MSW-only leachates respectively) while the levels of the other soluble ions in these leachates are similar to these levels in other IW leachates.

Solidification of the CPB before codisposal does lower the levels of soluble salts in the leachates, but not below problem levels. Further, although

TABLE 50. SUMMARY OF AVERAGE LEACHATE PARAMETERS FROM ALL TEST CELLS

Test Cell Contents	pH	Conductivity	Chemical oxygen demand	Biochemical oxygen demand	Total Organic Carbon	Alkalinity (as $CaCO_3$)	Total Volatile Acids	Total Kjeldahl Nitrogen	Total Phosphate
MSW-Only	5.31	6100	18,400	11,900	6000	2640	1280	542	22.6
EPW:									
Untreated	6.31	6900	14,300	5,700	4200	3810	933	421	4.75
Process A	5.31	6100	20,000	12,200	7600	2700	1930	517	16.5
Process B*	5.24	7500	23,900	13,400	8100	2960	2790	615	9.12
CPB:									
Untreated	6.19	30,500	16,200	9,880	5700	4440	2200	490	7.25
Process A	5.33	14,400	22,200	14,700	7550	3000	2920	628	15.3
Process B*	5.45	12,960	22,800	13,000	7840	3020	4120	607	16.9
GES:									
Untreated	6.62	6050	5,170	3,290	1690	3510	437	379	4.72
Process A	5.18	6570	21,600	15,200	6300	2910	2910	505	21.8
Process B	5.88	5630	12,200	11,300	4502	2520	345	401	11.0

NOTE: All values in mg/ℓ except pH (standard units) and conductivity (μmho/cm). MSW-only data from test cell 15 only.

* From below-soil samples; above-soil samples not available.

TABLE 51. SUMMARY OF AVERAGE LEACHATE CONCENTRATIONS OF MAJOR CATIONS AND CHLORIDE FROM ALL TEST CELLS

Test Cell Contents	Sodium	Potassium	Calcium	Magnesium	Aluminum	Iron	Manganese	Chloride
MSW-Only	377	326	520	86.9	0.459	323	10.0	567
MSW+EPW:								
Untreated	820	330	685	187	0.889	210	5.10	668
Process A	568	435	781	100	0.424	331	9.13	706
Process B*	724	525	833	132	0.560	357	14.4	804
MSW+CPB:								
Untreated	19,200	468	729	224	0.976	74.7	9.51	24,900
Process A	3,400	590	884	131	0.682	305	11.8	4,470
Process B*	2,500	564	819	212	0.562	364	12.6	4,270
MSW+GES:								
Untreated	563	337	298	234	0.805	87.6	19.2	754
Process A	584	450	851	118	0.735	318	10.8	658
Process B	497	350	643	113	1.30	184	7.1	638

NOTE: All values in mg/ℓ. MSW-only data from test cell 15 only.
* From below-soil samples; above-soil samples not available.

treatment did lower the initial very high levels of soluble constituents from these CPB containing test cells, over the long term their levels remained quite high and stable for the entire leaching period (see Figures 38 and 39). This would indicate that these losses would probably continue at these elevated levels for extended periods of time from the treated CPB.

The alkali and alkaline-earth cations can be inhibitory to anaerobic digestors at certain ranges of concentrations. Pohland (15) has summarized these effects which are shown in Table 52. The moderately inhibitory levels are those which normally could be tolerated after extended acclimation by the microorganisms. Sodium levels in the test cell containing untreated CPB fell well in the strongly inhibitory range and remained at these levels for over two years of leaching before dropping below 10,000 mg/l (see also Fig. 39). Test cells containing both treated CPB samples in the MSW produced leachates which had lower sodium levels. Sodium concentrations were 5000 to 6000 mg/l at their highest level but remained at consistently elevated levels throughout the leaching period.

The divalent cations, calcium and magnesium, are prevalent in all leachate samples, generally being 1 to 2 times higher in test cells containing either treated or untreated IW. Calcium occurs near its solubility limit (for calcium hydroxide or sulfate) and remains so in all test cells containing either treated or untreated IWs which must contain appreciable amounts of lime and/or gypsum. Test cells with treated IW have leachates which consistently show higher calcium levels than those from the untreated IW cells, probably because of their more acidic pH's. Calcium levels in the MSW-only, test-cell leachates fall from levels above 1000 mg/l in the first year of leaching to a stable level around 300 mg/l over the last two years of leaching. Magnesium is consistently higher in leachates from IW containing test cells, the untreated IW cells showing higher and more persistent concentrations.

Iron is an exception to the above generalization in that its concentration is much lower in leachates from all test cells containing untreated IW than in either MSW-only or MSW plus treated IW test cell leachates. The amount of iron present in the MSW leachates is largely a function of either its solubility or its rate of reduction from the ferric to the more soluble ferrous form by the iron reducing bacteria. Iron is the only major element whose concentration in the leachates generally increases over the leaching period. The more basic pH levels in the untreated IW-MSW leachates may lower its solubility or increase its rate of oxidation to the much-less-soluble ferric (+3) state. Or perhaps a lower action of the iron-reducing bacterial in the untreated-IW-containing test cells may cause the lower, iron leaching rates from these test cells.

Iron is generally quite abundant in most soils but is itself rarely deleterious to environmental quality. However, 0.3 mg/l is the maximum permissible level of iron in drinking water (32, 33). This standard was selected primary on esthetic grounds rather than for health reasons. Iron chemistry and prevalence is important because of its interaction with other, toxic, heavy metal ions. These other heavy metals are largely taken out of solution by sorption to iron (and manganese) oxides by ion exchange or surface complex reactions (37).

TABLE 52. STIMULATING AND INHIBITORY CONCENTRATIONS OF ALKALI AND ALKALINE-EARTH CATIONS TO AN ANAEROBIC DIGESTOR

Cation	Stimulatory	Moderately Inhibitory	Strongly Inhibitory
Sodium	100-200	3500-5500	8,000
Potassium	200-400	2500-4500	12,000
Calcium	100-200	2500-4500	8,000
Magnesium	75-150	1000-1500	3,000

NOTE: All values in mg/l. Taken from Pohland (1978).

Manganese levels in leachates from test cells containing treated or untreated IW typically varied around the levels found in the MSW-only (50 to 190% on the average), most being within 20 to 30% of the control MSW-only levels. The addition of IW apparently had little or no major effect on these levels.

Heavy Metals and Other Minor Constituents

The average levels of the toxic materials in the leachates are summarized in Table 53. The current EPA drinking water standards (DWS) are included for those ions for which standards have been established for comparison only as they have no regulatory basis in this regard. Note that levels of all these parameters are typically found near DWS levels and that all exceed DWS in average concentration in leachates from at least 2 IW containing test cells. The worst cases, chromium and selenium, uniformly average above DWS in all leachates, and arsenic exceeds DWS from 8 of the 10 test cells. Also, since these levels are averaged over 4 years of leaching, a great many individual leachate samples would be expected to have levels several times these average values (see Highest Levels Found in Tables 17 and 28 in Sections 4 and 5).

Excursions in concentration of these materials from the levels found in MSW-only leachates are typically very small when compared to the total amounts of the metals added to the test cells with the IW's is considered, especially for the EPW. For example, added with the untreated EPW in the test cells were over 70 kg of copper and 45 kg of chromium; however, only 72 and 780 mg of each, respectively, (both about double that leached from the MSW-only test cells) were leached over the entire 4 year period. Evidently the factors (e.g., solubility, organic complexation or chelation) which limit their concentration in the leachates are largely independent of the amount of the constituent present in the waste.

The chemistry of the trace metals in natural systems is immensely complex. For most metals, it is not possible to predict quantitatively the concentrations of the numerous possible forms of a particular metal in a typically heterogeneous, leachate system based upon the behavior of the metal in pure systems (36, 37, 38). For instance, the solubility product constants of leach carbonate, hydroxide, phosphate, sulfide and sulfate are reported as

TABLE 53. SUMMARY OF AVERAGE CONCENTRATIONS OF PARAMETER IN ABOVE-SOIL SAMPLES AND EPA DRINKING WATER STANDARDS FOR TOXIC LEACHATE COMPONENTS

Test Cell Contents	Parameter Concentration (mg/ℓ)										
	Cadmium	Chromium	Copper	Lead	Nickel	Mercury	Zinc	Selenium	Arsenic	Fluoride	Boron
MSW-only	0.004	0.13	0.010	0.04	0.229	0.001	7.90	0.10	0.08	0.15	2.38
EPW:											
Untreated	0.010	0.24	0.022	0.01	0.285	0.001	3.29	0.07	0.13	0.67	9.80
Process A	0.004	0.12	0.015	0.05	0.324	0.001	4.80	0.02	0.05	0.29	3.82
Process B*	0.009	0.09	0.009	0.02	0.378	0.002	13.8	0.12	0.04	0.30	6.25
CPB:											
Untreated	0.120	0.15	0.055	0.10	0.319	0.016	16.4	0.38	0.10	3.4	3.76
Process A	0.004	0.11	0.037	0.04	0.286	0.001	16.6	0.12	0.04	1.2	3.69
Process B*	0.004	0.18	0.018	0.05	0.273	0.003	7.43	0.19	0.13	0.32	21.9
GES:											
Untreated	0.010	0.07	0.012	0.02	0.167	0.009	0.385	0.18	0.06	1.4	3.21
Process A	0.003	0.14	0.013	0.03	0.226	0.002	11.1	0.08	0.06	0.24	4.24
Process B	0.005	0.08	0.011	0.01	0.166	0.002	7.07	0.12	0.06	0.48	9.88
Drinking Water Standard**	0.010	0.05	None	0.05	None	0.002	None	0.01	0.05	1.4-2.4	None

NOTE: All values in mg/ℓ. MSW-only data from test cell 15 only.

* From below-soil samples; above-soil samples not available.

** From U. S. Public Health Service, 1962 and USEPA, 1973; none indicates no standard set.

10^{-14}, 10^{-15}, 10^{-42}, 10^{-28}, and 10^{-8} respectively. Thus in the presence of these ligands, lead is only sparingly soluble. However, it is not usually possible to explain trace metal levels in natural systems by the application of these solubility data such as these, or to project or speculate on the predominant regulatory mechanisms affecting trace metal chemistry and their effects on the metal concentrations in leaching systems. Other complex factors such as trace metal-organic matter associations interact with the known chemistry of the metal. The chemical environment affecting the complex trace metal regulatory mechanisms is subject to considerable variability when codisposed with an amorphous mixture such as raw MSW. Detailed analysis of the chemical basis of the concentrations of trace materials found in the leachates of this study is beyond the scope of this report.

Although cadmium is a relatively rare element in the earth's crust, its high toxicity, its common appearance in waste streams and its propensity for bioaccumulation in plants makes it one of primary concern in most leachates (24, 38). Chemically it is closely related to zinc and in nature is always found associated with it. Cadmium is a divalent metal, readily forming halides of which chloride is the most reactive. Cadmium levels were elevated to about the same extent (250 to 300%) and exceeded DWS in all leachates from test cells containing untreated IW in spite of their higher pH values. Solidification of the IW by either process appeared to limit the levels of cadmium to that typically seen in the MSW-only leachates.

Chromium has two important oxidation states, trivalent (+3) and hexavalent (+6); the latter being widely used in metal finishing and plating industries. Only in the leachates from the untreated EPW were total chromium levels elevated over the MSW-only leachates (by less than 200%), even though all leachates exceeded DWS. As stated above, of the 45,760 g of chromium added to the MSW in the 704 kg of untreated EPW, only 0.49 g more chromium was seen in the leachate from this test cell than in the leachate from the MSW-only test cells (0.58 g). In a previous 2 year leaching study of untreated EPW alone (17), the average concentration was found to be only 0.043 mg/l with 0.095 mg/l maximum. The presence of the MSW in the test cell apparently helped to lower the chromium level over that which might be expected for EPW alone by about 50%.

Copper chemistry is also similar to zinc, although in general, equivalent copper compounds are less soluble. The stable form in natural environments is the cupric (+2) ion. The cuprous (+1) ion is unstable at ordinary temperatures but can be important under the highly reducing conditions which may be encountered in sanitary landfills. No microbes have been isolated which use copper as a terminal oxidant as in the cases of manganese or iron reducing bacteria. Copper has been implicated to be very toxic to methanogenic bacteria under some conditions (25). Average copper levels are seen to be elevated over MSW-only levels in leachates from test cells containing both untreated EPW (220%) and CPB (550%) and in CPB treated by either Process A (370%) or Process B (180%). The higher levels from CPB containing test cells reflect differences in solubility in the leachates as the CPB contained only about 0.7% of the copper in the EPW. This again illustrates the dramatic differences between leachate concentration for minor leachate constituents which are more directly related to solubility or complexation factors than the amount present to be leached.

Lead is the most abundant in the earths crust of the heavy element having atomic numbers greater than 60 and has been a potential environmental hazard to humans for over 4000 years (37). Lead was found in average concentrations at or just below DWS in all of the leachates. Highest lead levels were again seen in leachates from the test cells containing untreated CPB where they averaged 250% of the MSW-only leachates. Although lead was not a major component of any of the IW's, (26-300 mg/kg dry sludge solids) the CPB again contained the lowest amount, and even the less than 1% of the added lead was seen in the leachate (477 mg total leached).

Nickel is present in all leachates at an average level of between 0.16 and 0.38 mg/l, the treated samples of EPW and the untreated CPB producing leachates with the highest levels (0.32-0.38 mg/l). None of the leachates had even twice the average nickel found in the MSW-only leachate, or were any at problem levels.

Zinc is known to be the most mobile of the heavy metals. It exists only in the +2 oxidation state. Zinc compounds formed with the common anions of surface waters and landfill leachates are soluble in neutral and acid conditions although zinc sulfide is relatively insoluble and stable under reducing conditions. Zinc carbonate is typically formed under microaerophillic conditions when high levels of carbon dioxide are present and typically limits zinc solubility around neutrality. Zinc was present in MSW-only leachates at an average of about 8 mg/l. Nearly equal amounts were found in all other leachates except for lower levels (50%) in untreated and Process A EPW (which contained the only appreciable amount in the raw sludge) and very low levels (5%) in untreated GES; and elevated levels (~ 200% of MSW-only) in untreated and Process A CPB.

Mercury occurs as free metal (0) and oxidation states of +1 and +2 depending upon the redox conditions of its environment. Free, elemental mercury only occurs under very reducing conditions and has a solubility estimated to be near 50 micrograms/l (39). Mercury also forms soluble organic compounds in reducing environments which are responsible for much of its mobility and biological uptake. Both elemental and dimethyl mercury are quite volatile, making their loss through atmospheric routes an important but difficult to assess pathway. Mercury levels averaging near DWS were found in all leachates, exceeding DWS in 6 of the ten lysimeters. Both the untreated CPB and GES had very high mercury levels being 9 to 16 time the MSW-only average levels even though neither sludge contained appreciable amounts (6 to 120 mg/kg dry sludge solids).

Selenium is closely related to sulfur both chemically and biologically as it can substitute for it in many organic molecules. Like sulfur it is a metalloid and exists in oxidation states of -2 (as selenides) and +4 (as selenious ion) and +6 (selenic ion). Salts of selenic acid rarely are found in nature; if they form they are readily reduced to selenites and/or free selenium. Selenium exceeded DWS by an average of over 10 times in all leachates including the MSW-only leachates. Highest levels were seen in untreated CPB leachates and several others had levels between 100 and 200% of the MSW-only leachates.

Arsenic is a toxic metal in all its chemical forms. It exists as metallic arsenic (0), trivalent (+3) and pentavalent (+5) arsenic. The trivalent state is considerably more soluble than the more oxidized state so that its solubility generally increases under reducing conditions. Arsenate has very similar size and molecular configuration to the phosphate ion which it readily replaces in organic compounds (basis of its toxicity) and phosphate crystals. Arsenic was found at average concentrations near DWS in all leachates, exceeding them by small amounts in 8 of the 10 leachates, falling between 50 and 150% of the MSW-only leachate concentration in all cases.

Fluoride, the toxic analog of chloride, was found at elevated levels in all leachates, especially the untreated CPB and GES leachates in which it exceeded DWS and MSW-only leachate levels by 10 to 20 times. Boron showed similar elevated levels over the MSW-only leachates in all leachates, especially in the untreated EPW and in all IW's treated by Process B. Process B may have added appreciable boron in its treatment reagents.

All forms and types of IW used in the study impacted the levels of some of the leachate parameters. Except in the cases of the soluble salts (like NaCl), the relative levels of most parameters did not directly reflect their enrichment in the added IWs. Solubility and common ion effects appear to be major contributors to their leachate concentrations.

LEACHATE INTERACTIONS WITH SOIL LAYER

Considerable discussion and study has gone into the problem of interaction of leachates with underlying soils which are above the water table, usually from the point of view of the attenuation of leachate contamination by soil passage (14, 39, 40, 41, 42, 43). These earlier studies measured leachate-soil interactions in the first few, soil-pore-volumes or in batch mixtures during which time most dilution, dispersion and sorption phenomena are believed to be saturated. A very large degree of variation between different soil-leachate combinations were reported; some determinant variables were leachate and soil pH, soil clay content and actual leachate composition making extrapolations between different systems impossible (40, 42).

The soil-leachate interaction data from this study are not directly comparable to the earlier ones due to the acid soils (soil water pH=4.5) and the very large leachate to soil proportions (approximate 108 soil pore volumes were collected over the length of the study). Thus the effects of leachate upon the soil in this study represents a long-term exposure of the sub-landfill soil layer with monthly saturation to obtain the above-soil leachate samples. The long-term gain or loss of all constituents in the acidic, high-iron soil layer is shown in Table 54. Compared there are the average concentrations above- and below-soil layer calculated over the pooled leachates from all test cells for the complete study.

All measures of organic leachate constituents--BOD, COD, TOC and TVA--increased by 10 to 20% in the soil layer. The soil layers lost to the leachates an average of 5.8 g COD, 3.6 g BOD, 1.3 g TOC and 1.7 g TVA all per kg of wet soil in the test cell. In the literature, organic leachate parameters have not been found to be strongly affected by passage through the soil in the short term (39, 40, 41). Organic nitrogen also was leached from the soil (140 mg/kg soil), while total phosphate was gained by the soil, removing 62% of the phosphate from the leachate (30 mg/kg soil).

TABLE 54. AVERAGE OF ALL SAMPLES TAKEN ABOVE-SOIL OR BELOW-SOIL AND THEIR RATIOS

Parameter	Avg. of all Above-Soil Samples (mg/ℓ)	Avg. of all Below-Soil Samples (mg/ℓ)	Avg. Diff. in Conc. after passing through soil (mg/ℓ)	Avg. Mass gained(+) or lost(-) by leachate* (g)
Aluminum	2.63	2.08	-0.55	-2.38
Beryllium	0.032	0.017	-0.015	-0.065
Cadmium	0.0158	0.0139	-0.0017	-0.007
Chromium	0.125	0.108	-0.017	-0.074
Copper	0.020	0.023	+0.003	+0.013
Iron	269.	344.	+75.	+325.
Lead	0.033	0.038	+0.005	+0.022
Manganese	15.6	9.7	-3.9	-16.9
Mercury	ND**	ND	ND	ND
Nickel	0.237	0.238	+0.001	+0.004
Selenium	0.131	0.136	+0.005	+0.022
Zinc	8.85	7.82	-1.03	-4.46
Calcium	642	665	+23.	+99.7
Magnesium	133	142	+9.	+39.0
Potassium	391	424	+33.	+143.
Sodium	2490	2520	+30.	+130.
Arsenic	0.150	0.076	-0.74	-3.20
Boron	4.65	6.17	+1.52	+6.59
Chloride	3250	3130	-120	-520
Fluoride	0.82	2.42	+1.60	+6.93
COD	17540	19480	+1940	+8410.
BOD	11000	12200	+1200	+5200.
TOC	5780	6200	+420	+1820.
Alkalinity	2970	2950	-20	-86.7
Vol. Acids	1521	2100	+579	+2510
TKN	495	541	+46	+199.
Total Phosphate	15.4	5.83	-9.57	-41.5

* Out of 1440 kg of soil loaded into test cell and 4334 ℓ total leachate (average per test cell).

** Insufficient data above detection limits.

Of the heavy metals, iron was leached from soil layer (225 mg/kg soil average) increasing its leachate concentration by about 30%. The bulk of loss of iron from the soil layer occurred in the first few pore volumes of leachate (see Figures 22 and 23); this "Fe flush" (41) is probably due to its reduction on the clay surfaces by the anaerobic leachates. Aluminum (1.6 mg/kg soil), manganese (12 mg/kg soil) and zinc (3 mg/kg soil) were removed from the leachate by the soil layer. Other heavy metals were not appreciably affected by passage through the soil layer on the average.

The common cations--Ca, Mg, Na and K--were uniformly leached from the soil layer in small amounts (25 to 100 mg/kg soil) which increased their leachate concentrations by less than 10% in all cases (about 1% for sodium which is well within the experimental error). The loss of these ions, especially calcium and magnesium in the first leachates, is presumed to be due to the exchange with the high concentrations of other cations found in the leachates (41). Chloride, the major anion, was not changed in concentration appreciably by the soil layer (less than 4% which again is probably within experimental error). About half of the relatively low level of arsenic was removed from the leachates in the soil (2.2 mg/kg soil). Boron and fluoride were both added to the leachates by the soil layer, increasing the average concentrations by around 2 mg/l in both cases.

Leachates have been found to have dramatic effects upon underlying soils by exchanging some cation for others (largely by losing calcium and magnesium by exchange and iron and manganese by reduction to more soluble forms). Ultimately the soils may lose their structure which leads to clay dispersion and reduction in pore space greatly lessening its permeability (43). The addition of bacterial action from the added organic matter may also cause structural changes and permeability losses (40). The unpredictability of these interactions makes specific testing necessary for any given site.

References

1. Fields, T. F., and A. W. Lindsey. 1975. Landfill Disposal of Hazardous Waste: A Review of Literature and Known Approaches. EPA-503/2-78-158. U. S. Environmental Protection Agency, Washington, D. C.

2. Eichenberger, B., J. Edwards, K. Y. Chen and R. Stephens. 1978. Hazardous Wastes Input into Class I Landfills. Journal of Environ. Eng. Div., ASCE, 104 (EE3):385-399.

3. U. S. EPA. 1980. Codisposal of Municipal Solid Waste and Sewage Sludge. SW-184c. U. S. Environmental Protection Agency, Office of Water and Waste Management, Washington, D. C. 206 pp.

4. Houle, M. J., et al. 1977. Effects of Municipal Landfill Leachates on Release of Toxic Metals from Industrial Wastes. pp. 139-148. In: S. K. Banerji, ed., Management of Gas and Leachate in Landfills. EPA-600/9-77-026. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

5. Streng, D. R. 1977. The Effects of Industrial Sludges on Landfill Leachates and Gas. pp. 41-54. In: Management of Gas and Leachate in Landfills, EPA-600/9-77-026, S. K. Banerji, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

6. Swartzbaugh, J. T., R. L. Hentrich, and G. V. Sabel. 1978. Industrial and Municipal Wastes in a Landfill. pp. 129-152. In: Land Disposal of Hazardous Wastes, EPA-600/9-78-016, D. W. Shultz, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 435 pp.

7. Ham, R. K. and T. J. Bookter. 1982. Decomposition of Solid Waste in Test Lysimeters. J. Environ. Eng. Div., ASCE, 108(EE6):1147-1170.

8. Wilson, D. C. 1978. Recent Developments in the Management of Hazardous Wastes. AERER 9269, AERE Harwell, Oxfordshire, England. 47 pp.

9. Bromely, J. and D. C. Wilson. 1981. Codisposal of Toxics: A Legitimate Option. Waste Age, March, 1981, pp. 52-53.

10. Newton, J. R. 1977. Pilotscale Studies of the Leaching of Industrial Wastes in Simulated Landfills. Water Pollution Control 76(4):468-480.

11. Walsh, J. J. et al. 1983. Long-Term Impacts of Hazardous Waste Codisposal in Landfill Simulators. pp. 219-246. In: Land disposal of Hazardous Waste. Proceedings of the 9th Annual Research Symposium. EPA-600/9-83-018. U. S. Environmental Protection Agency, Cincinnati, OH. 416 pp.

12. McCabe, D. J. 1979. Environmental Assessment of the Disposal of Industrial Wastewater Residuals in a Sanitary Landfill. J. Environ. Sci. Health, A14(6):443-460.

13. Chan, K. Y., and F. R. Bowerman. 1974. Mechanism of Leachate Formation in Sanitary Landfills. In: Yen, T. F., Recycling and Disposal of Solid Wastes. Ann Arbor Science Publishers, Inc., Ann Arbor, MI. pp. 384-367.

14. Farquar, G. J. 1977. Leachate Treatment by Soil Methods. pp. 187-207. In: Management of Gas and Leachate in Landfills. S. K. Banerji, Ed. EPA-600/9-77-026. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

15. Pohland, F. G. 1975. Sanitary Landfill stabilization with Leachate Recycle and Residual Treatment. EPA-600/2-75-043. U. S. Environmental Protection Agency, Cincinnati, OH. 116 pp.

16. Malone, P. G. and L. W. Jones. 1979. Survey of Solidification/Stabilization Technology for Hazardous Industrial Wastes. EPA-600/2-79-056. U. S. Environmental Protection Agency, Cincinnati, OH. 43 pp.

17. Jones, L. W. and P. G. Malone. 1982. Disposal of Treated and Untreated Electroplating Waste in a Simulated Municipal Landfill. pp. 294-314. In: Landfill Disposal of Hazardous Waste. EPA-600/9-82-002. D. Shultz, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 549 pp.

18. Myers, T. E., J. C. Duke, Jr., P. G. Malone and D. W. Thompson. 1979. Gas Production in Sanitary Landfill Simulators. pp 5873. In: Municipal Solid Waste: Land Disposal. EPA-600/979-023a. M. P. Wanielistra and J. S. Taylor, ed. U. S. Environmental Protection Agency, Cincinnati, OH 437 pp.

19. Shafer, R. A., R. J. Larson, P. G. Malone and L. W. Jones. 1981. Gas Production in Municipal Waste Test Cells. In: Land Disposal: Municipal Solid Waste. EPA-600/9-81-002a. D. W. Shultz, Ed. U. S. Environmental Protection Agency, Cincinnati, OH. 255 pp.

20. Jones, L. W., R. J. Larson and P. G. Malone. 1984. Landfill Gas Production from Large Landfill Simulators. Environmental Laboratory, Waterways Experiment Station, U. S. Army Corps of Engineers. Final Report: Interagency agreement #EPA-IAG-D4-0569. U. S. Environmental Protection Agency, Cincinnati, OH. 85 pp.

21. Mahloch, J. L., D. E. Averett, and M. J. Bartos. 1976. Pollutant Potential of Raw and Chemically Fixed Hazardous Industrial Wastes and Flue Gas Desulfurization Sludges, Interim Report. EPA-600/2-76-182. U. S. Environmental Protection Agency, Cincinnati, OH.

22. Bartos, M. J., Jr., and M. R. Palermo. 1977. Physical and Engineering Properties of Hazardous Industrial Waste and Sludges. EPA-600/2-77-139. U. S. Environmental Protection Agency, Cincinnati, OH. 89 pp.

23. Jones, L. W. and P. G. Malone. 1982. Physical Properties and Leach Testing of Solidified/Stabilized Industrial Waste. EPA-600/2-82-099. U. S. Environmental Protection Agency, Cincinnati, OH. 149 pp.

24. Jackson, A. G. and D. R. Streng. 1976. Gas and leachate generation in various solid waste environments. In: Gas and Leachate from Landfills: Formation, Collection, and Treatment. EPA-600/9-76-004. U. S. Environmental Protection Agency, Cincinnati, OH.

25. Chian, E. S. K., F. B. DeWalle and E. Hammerberg. 1977. Effect of Moisture Regime and Other Factors on Municipal Solid Waste Stabilization. pp. 73-86. In: Management of Gas and Leachate in Landfills, EPA-600/9-77-026, S. E. Banerji, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

26. Eifert, M. C. and J. T. Swartzbaugh. 1977. Influence of Municipal Solid Waste Processing on Gas and Leachate Generation. pp. 55-72. In: Management of Gas and Leachate in Landfills. EPA-600/9-77-026. S. K. Banerji, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

27. Myers, T. E., et al. 1980. Chemically stabilized Industrial Wastes in a Landfill Environment. pp. 5873. In: Disposal of Hazardous Waste, EPA-600/9-80-010, D. Shultz, ed. U. S. Environmental Protection Agency, Cincinnati, OH. 301 pp.

28. Jones, L. W., R. J. Larson, T. E. Myers and P. G. Malone. 1983. Large Scale Simulation of Land Disposal of Treated and Untreated Flue Gas Desulfurization Wastes. Environmental Laboratory, Waterways Experiment Station, U. S. Army Corps of Engineers. Final Report: Interagency Agreement #EPA-IAG-D4-0569. U. S. Environmental Protection Agency, Cincinnati, OH. 124 pp.

29. Larson, R. J., D. W. Thompson and P. G. Malone. 1984. Evaluation of the RCRA Extraction Procedure - Lysimeter Studies with Municipal/Industrial Wastes. Environmental Laboratory, Waterways Experiment Station, U. S. Army Corps of Engineers. Final Report: IA #IAG-AD-F-1-347. U. S. Environmental Protection Agency, Cincinnati, OH. 67 pp.

30. Fenn, D. G., K. J. Hanley and T. V. DeGaere. 1975. Use of Water Balance Method for Predicting Leachate Generation from Solid Waste Disposal Sites. EPA-530/SW-168. U. S. Environmental Protection Agency, Washington, D. C.

31. Chian, E. S. K. and F. B. DeWalle. 1977. Evaluation of Leachate Treatment. Vol. I: Characterization of Leachate. EPA-600/2-77-186a. 226 pp. Vol. II: Biological and Physical-Chemical Processes. EPA-600/2-77-186b. 256 pp. U. S. Environmental Protection Agency, Cincinnati, OH.

32. U. S. Public Health Service. 1962. Drinking Water Standards. U. S. Public Health Service, Pub. 956, Washington, D. C.

33. U. S. EPA. 1973. Proposed Criteria for Water Quality. Vol. I and Vol II. U. S. Environmental Protection Agency, Washington, D. C.

34. APHA. 1976. Standard Methods in the Examination of Water and Waste Water, 14th Ed. American Public Health Association, Washington, D. C.

35. SAS Institute Inc. 1982. SAS User's Guide: Statistics. SAS Institute Inc. Cary, NC. 584 pp.

36. Gambrell, R. P., et. al. 1977. Transformations of Heavy Metals and Plant Nutrients in Dredged Sediments as Affected by Oxidation Reduction Potential and pH. Vol. II, Materials and Methods/Results and Discussion. Contract Report D-77-4, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 336 pp.

37. Khalid, R. A., et. al. 1977. Transformations of Heavy Metals and Plant Nutrients in Dredged Sediments as Affected by Oxidation Reduction Potential and pH. Vol. I: Literature Review. Contract Report D-77-4. U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 238 pp.

38. Phung, T. et. al. 1978. Land Cultivation of Industrial Wastes and Municipal Solid Wastes: State-of-the-Art Study. Vol. I, Technical Summary and Literature Review. EPA-600/2-78-140a. 220 pp. Vol. II, Field Investigations and Case Studies. EPA-600/2-78-140b. 173 pp. U. S. Environmental Protection Agency, Cincinnati, OH.

39. Fuller, W. H. 1978. Investigation of Landfill Leachate Pollutant Attenuation by Soils. EPA-600/2-78-158. U. S. Environmental Protection Agency, Cincinnati, OH. 239 pp.

40. Farquar, G. J. and F. A. Rovers. 1975. Leachate Attenuation in Undisturbed and Remoulded Soils. pp. 54-70. In: Gas and Leachate from Landfills: Formation, Collection and Treatment. Proceeding of a Research Symposium, Rutgers University, New Brunswick, NJ. March, 1975.

41. Griffin, R. A. and N. F. Shrimp. 1976. Leachate Migration Through Selected Clays. pp. 92-95. In: Gas and Leachate from Landfills. E. J. Genetelli and J. Cirello, Eds. EPA-600/9-76-004. U. S. Environmental Protection Agency, Cincinnati, OH.

42. Roulier, M. H. 1977. Attenuation of Leachate Pollutants by Soils. pp. 127-138. In: Management of Gas and Leachate in Landfills. S. K. Banerji, ed. EPA-600/9-77-026. U. S. Environmental Protection Agency, Cincinnati, OH. 297 pp.

43. Chan, K. Y. 1982. Changes to a Soil on Irrigation with a Sanitary Landfill Leachate. Water, Air and Soil Pollution 17:295-304.

APPENDIX A
METAL ANALYSIS OF BULK SLUDGES

The best procedure for the analysis of waste sludges samples for more than one or two elements vary with type of sludge and the elements to be assayed. Each waste material is different and subject to different problems in analysis. An analytical scheme must consider losses during pretreatment or digestion and interferences inherent in the analytical instrumentation and techniques used. For the purposes of this study a limited comparison of chemical digestion procedures and instrumental techniques was performed and is only briefly reported here.

The sludges were digested and/or analyzed by eleven different procedures for comparative purposes as listed in Table A-1. Two methods used low temperature ashing as a sample destruction, four used the bomb technique of Eggiman and Betzer (1), one used a Parr bomb, and three used modifications of the open beaker technique of the U. S. EPA (2). In two of the beaker techniques hydrochloric acid was not used; in the third, hydrofluoric acid was included. These samples were analysed using atomic absorption spectrometry (AAS). Sludge samples were also subjected to nondestructive neutron activation analysis (NAA) consisting of a short irradiation time (time of irradiation less than 5 min) followed by counting after a decay period of a few minutes (depending upon the induced activity) and a long irradiation of several hours duration followed by counting after two weeks decay time.

A complete listing of the metal analyses for the three sludges used in this study are shown in Tables A-2, A-3 and A-4. Sample means and standard deviations were calculated for each metal in each sludge. To compare effectiveness of the methodologies, the data were tested for significance using Student's T-statistic. Values in the Tables indicated by an asterisk (*) are outside a two-sided 99 percent confidence interval for the average of the determinations of all of the digestion/analytical techniques that gave results above the detection limit. Method 4, the Eggiman and Betzer (1) bomb method with aqua regia (nitric acid), gave the fewest values outside the 99% significance and appeared to be the best overall method. The methods employing low temperature ashing tended to given high results. The methods which used hydrofluoric acid in sample digestion gave high results for potassium, iron and sodium. Analysis by nondestructive neutron activation analysis was significantly different in only 1 out of 21 analyses.

Since replicate determinations for each method were not performed, the possibility that variation in sample composition accounts for the significant differences observed cannot be discounted. Whenever small amounts of sample are digested as in this study (0.1 to 2 g), the results are vulnerable to chance variation in sample composition.

Estimates of the concentration of each metal in each sludge are presented in the Methods and Materials Section of this report (Table 2). These estimates were derived as follows: for those elements for which all the data fell within the two-sided 99% confidence interval based upon the t-values for (n - 1) degrees of freedom, the mean value of all methods employed is listed. If one or more values were outside the two-sided 99% confidence interval (those values marked by an asterisk in Tables A-2, A-3 and A-4), then an iterative process of disregarding the outliers and recalculating the sample mean

TABLE A-1. METHODS OF SLUDGE DIGESTION AND ANALYSIS FOR METALS

Code No.	Digestion Procedure	Analysis Technique
1	Oven dry at 60C, Low Temp. Ash (LTA), dissolve in nitric and HCl.	Flame- and HGA-AAS
2	LTA wet sludge and continue as in 1.	Same as 1
3	Oven dry, Eggiman and Betzer (1) bomb using nitric acid	Same as 1
4	Same as 3 but with wet sludge	Same as 1
5	Same as 3 but using nitric acid	Same as 1
6	Same as 3 but using wet sludge with nitric acid	Same as 1
7	Wet sludge, Parr Bomb with nitric and HF acids.	See Table 7
8	Wet sludge, open beaker (TEP) Nitric acid only	Same as 1
9	Oven dry sludge, open beaker (TEP), nitric acid only	Same as 1
10	Wet sludge, covered beaker (TEP) nitric, HCl and HF acids	See Table 7
11	None	Nondestructive Neutron Activation analysis

Note: HGA-AAS = Heated graphite atomized-atomic absorption spectrophotometer.

was conducted until all values in the 99 percentile of the Student's t-distribution were included. In no case was less than four degrees of freedom included in the calculations.

TABLE A-2. CONCENTRATIONS OF METALS IN ELECTROPLATING WASTE (EPW)

Method of Analysis	Destruction Technique (Table A-1)	METAL											
		Ca(%)	Mg(%)	Si(%)	K(%)	Na(%)	Sr(%)	Fe(%)	B(%)^d	Zn(%)	Ba(%)	Cr(%)	Ni(%)
AAS	1	9.7	0.88*	0.010	0.098*	2.0*	0.052*	1.0	<0.19	1.3*	0.13	16	0.43*
	2	0.49	0.52	0.020	0.004	1.2*	0.054*	0.79	<0.26	1.3*	0.73*	13	0.21
	3	1.0	0.54	0.028	0.028	0.98	0.039	3.2*	<0.30	0.79	0.20*	8.1	0.31
	4	1.0	0.60	0.050	0.046	0.74	0.038	0.77	<0.30	0.76	0.32*	7.6	0.33
	5	2.0	0.60	0.017	0.095*	0.65	0.031	1.8*	<0.17	0.78	0.027	5.3	0.33
	6	8.2	0.45	0.071*	0.058	0.86	0.029	0.72	<0.18	0.78	0.044	6.7	0.24
	8	9.2	0.51	0.057	0.055	0.84	0.024	0.92	<0.12	0.88*	0.068	4.7	0.25
	9	9.5	0.26*	0.044	0.046	1.0	0.019	0.56	<0.10	0.78	0.018	5.8	0.19
NAA	11 Non-destructive	6.6± 0.3	--	--	--	--	--	1.4± 0.1	--	0.78± 0.05	--	7.3± 0.2	--

Method of Analysis	Destruction Technique (Table A1)	METAL										
		Cu(%)	Mn(%)	Pb(%)	As(µg/g)	Ag(µg/g)	Se(µg/g)	Cd(µg/g)	Be(µg/g)	Sb(µg/g)	V(µg/g)	Al(%)
AAS	1	12	0.020	0.16*	50	14	19	1300*	570	15*		
	2	14*	0.034*	0.034	36	5.9	23*	470	730*	12		
	3	11	0.012	0.071	45	2.2*	20	760	560	5.2		
	4	10	0.010	0.064	49	7.3	26*	380	480	2.8		
	5	--	0.034*	0.064	52*	6.3	19	420	320	11		
	6	10	0.008	0.049	33	51*	18	280	410	4.3		
	8	8.3	0.008	0.077	34	9.6	16	930*	340	3.2		
	9	7.8	0.011	0.025*	31	6.9	14	410	330	14		
NAA	11 Non-destructive	--	0.028± 0.001	--	n.d.	<19	<67	720± 67	--	18± 2	17± 1	0.47± 0.04

[d] All values below detection limit of ~20 ppm in solution analyzed

* Values not normally distributed with respect to average of AAS analysis.

TABLE A-3. CONCENTRATIONS OF METALS IN CHLORINE PRODUCTION BRINE (CPB)

Method of Analysis	Destruction Technique (Table A-1)	METAL											
		Ca(%)	Mg(%)	Si(%)	K(%)	Na(%)	Sr(%)	Fe(%)	B(%)[d]	Zn(%)	Ba(%)	Cr(%)	Ni(%)
	1	34	0.34*	0.092*	6.3*	6.6*	0.19	0.27*	<0.11	0.016	0.080*	0.51*	0.0055
	2	4.2*	0.12	0.063	0.016*	7.4*	0.21*	0.21	<0.07	0.017*	0.059	0.14	0.011
	3	25	0.13	0.067	0.013	7.4*	0.13	0.18	<0.16	0.012	0.045	0.072	0.039*
	4	30	0.13	0.046	0.010	3.7	0.15	0.19	<0.07	0.011	0.060	0.049	0.0022
AAS	5	22*	0.16	0.037	0.012	4.5	0.12	0.41*	<0.15	0.016	0.033	0.075*	0.025*
	6	29	0.13	0.016	0.010	5.0	0.15	0.21	<0.06	0.012	0.035	0.11	0.0047
	8	32	0.20*	0.015	0.013	5.0	0.02*	0.26*	<0.04	0.011	0.037	0.18	0.0037
	9	27	0.32*	0.024	0.013	4.3	0.15	0.19	<0.09	0.010	0.059	0.15	0.0084
NAA	11 Non-Destructive	21± 1	--	--	--	--	--	0.25± 0.02	--	0.014± 0.001	--	0.0029± 0.0003	--

Method of Analysis	Destruction Technique (Table A1)	METAL										
		Cu(%)	Mn(%)	Pb(%)	As(ug/g)	Ag(ug/g)	Se(ug/g)	Cd(ug/g)	Be(ug/g)	Sb(ug/g)	V(ug/g)	Al(%)
	1	0.086*	0.010	0.0049*	47*	0.32*	13	0.93	0.068	0.80		
	2	0.016	0.022*	0.0032	18	0.020	14	0.78	0.090	0.37		
	3	0.12*	0.0076	0.0081*	18	1.5*	14	0.51*	0.17*	1.1		
	4	0.035	0.0060	0.0026	14	0.10	11	0.76	0.080	0.37		
AAS	5	0.048*	0.014*	0.0037	15	0.10	14	0.91	0.12*	1.3		
	6	0.025	0.0059	0.0023	13	0.037	8.5*	1.1	0.093	1.4		
	8	0.028	0.0044	0.0016	13	0.010	11	1.3*	0.060	0.12		
	9	0.029	0.0076	0.0021	15	0.020	12	0.69	0.090	45*		
NAA	11 Non-destructive	--	0.018± 0.001	--	n.d.	<8	<8	<70	--	<2	<17	<0.12

[d] All values below detection limit of ~20 ppm in solution analyzed

* Values not normally distributed with respect to average of AAS analysis.

TABLE A-4. CONCENTRATIONS OF METALS IN GLASS-ELECTRONICS ETCHING SLUDGE (GES)

Method of Analysis	Destruction Technique (Table A-1)	METAL											
		Ca(%)	Mg(%)	Si(%)	K(%)	Na(%)	Sr(%)	Fe(%)	B(%)^d	Zn(%)	Ba(%)	Cr(%)	Ni(%)
AAS	1	32*	1.3*	4.0	0.21	0.16	0.026	0.61	<0.12	0.057*	0.087*	0.091*	0.15*
	2	48*	0.20*	4.6	0.20	0.22*	0.015	0.65	<0.19	0.051*	0.071*	0.024	0.035
	3	30	0.98	3.3	0.22	0.17	0.024	0.55*	<0.14	0.028	0.049	0.025	0.032
	4	28	0.95*	3.7	0.22	0.16	0.022	0.66	<0.10	0.036	0.054	0.030	0.050*
	5	27	1.0	3.4	0.23*	0.089*	0.020	0.68	<0.18	0.034	0.025	0.75*	0.039
	6	25	1.0	2.8	0.21	0.14*	0.019	0.74	<0.08	0.032	0.034	0.033	0.066*
	8	29	1.0	0.013*	0.19*	0.16	0.0096*	1.5*	<0.09	0.026	0.060	0.12*	0.032
	9	27	1.0	0.016*	0.21	0.16	0.015	0.63	<0.11	0.023	0.042	0.062	0.040
NAA	11 Non-destructive	16± 1	--	--	--	--	--	0.79± 0.05	--	0.033± 0.001	--	0.0077± 0.0006	--

Method of Analysis	Destruction Technique (Table A1)	METAL										
		Cu(%)	Mn(%)	Pb(%)	As(μg/g)	Ag(μg/g)	Se(μg/g)	Cd(μg/g)	Be(μg/g)	Sb(μg/g)	V(μg/g)	Al(%)
AAS	1	0.062*	0.036*	0.024	51	1.1	19*	4.7	0.35	2.4		
	2	0.017*	0.042*	0.015*	53*	7.5*	20*	3.5	0.30	2.0		
	3	0.046	0.017	0.023	37	1.0	16	5.3	0.37	2.3		
	4	0.048	0.013	0.025	40	0.57*	15	4.7	0.10	0.47		
	5	0.044	0.018	0.018	49	1.5	14	10*	0.16	0.42		
	6	0.048	0.029*	0.019	38	1.6	13	4.5	0.043	1.4		
	8	0.039	0.007	0.014	46	1.2	17	2.9	0.13	0.43		
	9	0.039	0.014	0.019	46	1.4	17	1.0*	0.45*	140*		
NAA	11 Non-destructive	--	0.026± 0.001	--	n.d.	<8	<12	--	--	19± 3	15± 2	1.6± 0.1

[d] All values below detection limit of ~20 ppm in solution analyzed

* Values not normally distributed with respect to average of AAS analysis.

REFERENCES

1. Eggiman, D. W., and P. R. Betzer. 1976. Decomposition and analysis of refractory oceanic suspended materials. Anal. Chem. 48:886-890.

2. U. S. EPA. 1974. Methods for Chemical Analysis of Water and Wastes. EPA-625/6-74-003a. U. S. Environmental Protection Agency, Washington, D. C. 298 pp.

APPENDIX B
CHARACTERISTIC OF SOIL LAYER IN TEST CELL

Those soil properties considered most important in the assessment of candidate soils were permeability, particle-size distribution (clay content), and cation exchange capacity (CEC). For this study, the soil permeability had to be clearly higher than the permeability of the overlying waste to avoid ponding of leachate at the interface. Because clays are the predominate particulate fraction involved in pollutant attenuation and retention, we attempted to keep the clay content of the soil selected as high as possible and still maintain adequate permeability. The higher the CEC, the greater the potential for pollutant uptake and retention from the passing leachate.

The soil selected was collected from the Camp Shelby Military Reservation, about 16 km south of Hattiesburg, MS. Each sample was a composite of the 6 cm to 152 horizons. The permeability and particle-size distribution, X-ray crystallography, and CEC were determined on the composited samples. A summary of the soil characteristics is given in Table B-1.

PARTICLE-SIZE DISTRIBUTION AND PERMEABILITY.

Particle-size distributions were determined by sieve analysis and the hydrometer method. A constant head permeability was determined with a confining pressure. The coefficient of permeability at a confining pressure of 0.14 kg/m^2 and at a dry density of 1766 kg/m^3 was 1,180 cm/sec. The confining pressure and dry density are estimates of field conditions. The soil has a SC-SM Unified Soil Classification.

X-RAY CRYSTALLOGRAPHY.

To check for the presence of hydrated halloysite a wet-ground slurry was put onto a 7.6 cm glass slide and examined while damp and again after drying. Further, about 4 g were ground to pass a 45 micron (No. 325) sieve and backpacked to minimize preferred orientation before X-raying. All X-rays were made with nickel-filter copper radiation.

Sedimented clay slides consisting of particles smaller than 2 microns were X-rayed air-dry and after saturation with glycerol to aid in the identification of smectite (swelling, montmorillonitic clay). In addition, sedimented slides were X-rayed after saturation with ethylene glycol to determine if expansion indicative of vermiculite occurred. To differentiate chlorite and vermiculite other sedimented slides were heated to 350C for 1 hour or to 600C for 2 hours before X-raying.

All of the samples contained the same minerals and were similar in composition. They were composed largely of quartz with small amounts of potassium feldspars and clays. The clays were kaolinite, clay-mica, vermiculite, and randomly mixed-layered cherite and clay-mica. The identification of the vermiculite and the mixed-layer clay components is tentative. There was no evidence of hydrated halloysite or smectite.

TABLE B-1. SUMMARY OF SOIL CHARACTERISTICS

Permeability: $1.18 \times 10^{-3}_{2}$ cm/sec at dry soil density of 1766 kg/m^3,
0.14 kg/m^2 confining pressure

Particle-size Distribution:
Clay (5μ) - 16%
Silt (5μ to 50μ) - 4%
Sand (50μ) - 80%

Unified Soil Classification: Clayey sand, SC-SM

Cation Exchange Capacity: 7.4 meq/100 g

Mineralogy: Largely quartz with small amounts of potassium feldspars and clays. Clays are mainly kaolinite; no hydrated halloysite or smectite.

Moisture: 7.36%

Color: Red

SCS Description: Typic Paleudults, coarse-loamy, siliceous, thermic. McLaurin series, of large extent. Sandy-loam A horizons and red, fine-sandy-loam B2t horizons

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ELEMENTAL PARTITIONING.

Elemental partitioning, the selective extraction of metals, is a means of determining which elements belong to the various geochemical phases that range from those forms reversibly adsorbed to the surfaces of soil particles to those tightly bound in the crystal lattices of the soil minerals. Forms in each geochemical phase are extracted by subjecting the same sample sequentially to harsher chemical treatment. These procedures follow the methods of Brannon, et al. (1) and Chen, et al. (2).

Exchangeable and Soluble Phases

The exchangeable plus soluble phases which are extracted by 1.0 M ammonium acetate, include mainly the fraction of each metal which is physically adsorbed at the charged surfaces of solid particles and metals dissolved in the pore water. This phase is thought to be in dynamic equilibrium.

Acetic Acid Extractable (Carbonate) Phase

Extraction of residue from the previous extraction with 1.0 M acetic acid releases primarily the metal-carbonate complexes.

Easily Reducible Phase

Extraction of the residue with 1.0 Hydroxylamine hydrochloride in 0.01 M nitric acid frees metals associated with manganese and amorphous iron hydroxide and hydrous oxide precipitates which are released into reducing solutions such as anaerobic MSW leachates.

Mineral Solubilization

Acid digestion with hydrofluoric and fuming nitric acids destroys the fundamental mineral lattice work and releases the remaining elements.

Soil at its natural moisture content was used in all extractions and digestions, with dry weight values obtained from separate subsamples at each state of the partitioning. Each residue was washed between subsequent extractions with deionized-distilled water. Extractions were conducted by shaking the extractant with the soil sample for 1 hour on a mechanical shaker, followed by centrifugation at 6000 RPM for 30 min and 0.45 micron membrane filtration. Six replicates and a reagent blank were carried through each step in the geochemical phase of the partitioning. Each replicate represents a separate subsample of the soil. Methods of metal analysis of the extractants are those given in the Methods and Materials section of this report.

Table B-2 lists the results of the geochemical partitioning of 16 different elements associated with the solid phase of the soil before placement in the test cells. An assessment of the attenuation of leachate contaminants by the soil can be made by comparison of above and below soil leachate quality in conjunction with a comparison of elemental partitioning of the soil before placement and after the leaching period is completed.

TABLE B-2. SELECTIVE SEQUENTIAL EXTRACTION OF SOIL USED IN TEST CELLS

	Exchangeable and soluble phase	Carbonate phase	Easily reducible phase	Total digestion	Total extracted
Arsenic	0.005*	0.029	0.209	3.95	4.19
Boron	0.948	0.291	0.208	10.7	12.3
Beryllium	<0.0042	0.134	ND†	0.378	(5.12)‡
Calcium	41.5	7.97	2.52	1.29	53.3
Cadmium	0.035	<0.017	<0.017	10.0	10.1
Chromium	0.040	0.069	0.036	17.0	17.1
Copper	0.034	0.052	0.094	2.21	2.40
Iron	3.38	5.01	20.0	4380	4410
Lead	0.007	0.047	0.135	1.11	1.30
Magnesium	6.58	0.54	1.02	6.71	14.8
Manganese	0.614	0.238	1.70	11.9	14.5
Nickel	<0.004	<0.026	<0.026	4.64	4.70
Potassium	4.0	<1.0	1.3	310	316
Selenium	0.014	0.069	0.240	0.287	0.610
Sodium	8.9	ND	ND	26.9	(35.8)
Zinc	1.03	ND	ND	11.2	(12.2)

* All values are in mg/kg dry weight of soil extracted and are average of 6 extraction replications.

† ND = no data.

‡ Parentheses indicate incomplete data for total extract.

REFERENCES.

1. Brannon, J. M., R. M. Engler, J. R. Rose, P. G. Hunt and I. Smith. 1976. Selective Analytical Partitioning of Sediments to Evaluate Potential Mobility of Chemical Constituents During Dredging and Disposal Operations. Technical Report D-76, U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

2. Chen, K. Y., S. K. Gupta, A. Z. Sycip, J. C. S. Lu, M. Knezevic and W-W. Choi. 1976. Research Study on the Effect of Dispersion, Settling and Resedimentation on Migration of Chemical Constituents During Open Water Disposal of Dredge Materials. Contract Report D-76-1. U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

APPENDIX C

LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY FOR ABOVE-SOIL AND BELOW-SOIL LEACHATE SAMPLES

TABLE C-1. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (10) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	2.150	4.350	13.9	B	1677.5	0.025	0.029	265.00	22.500
331	1.500	0.328	9.2900	B	1167.5	0.011	0.005	172.00	15.800
437	2.310	0.383	6.6300	B	970.0	0.020	0.023	120.00	10.430
514	0.465	0.197	1.8025	B	677.5	0.010	0.002	70.00	6.775
598	0.132	0.152	1.1900	B	477.5	B	0.002	45.50	4.975
689	0.110	0.137	0.9725	B	375.0	0.005	B	36.25	4.575
780	0.105	0.077	0.7225	B	362.5	B	0.020	17.27	4.325
878	1.150	0.050	0.6862	B	327.5	0.002	B	27.75	4.100
969	0.087	0.042	0.5400	B	345.0	0.025	0.002	26.75	4.000
1053	0.042	0.037	0.4950	B	292.5	0.010	0.002	22.20	3.950
1150	0.127	0.012	0.6975	B	260.0	0.002	0.003	20.75	1.470
1235	1.755	0.020	0.4780	B	200.0	0.005	0.070	15.90	3.950
1328	0.041	B	0.5880	B	251.0	B	0.043	22.50	5.780
1415	0.103	B	0.3800	B	263.0	0.018	0.013	23.70	5.750
1510	0.179	B	0.2420	B	91.5	0.005	0.008	7.58	2.060

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.448	1160.0	1225	0.068	0.204	44800	32000	1380	23.0	72.8
331	0.315	832.5	795	0.035	0.060	41800	33000	1220	25.9	113.9
437	0.021	562.5	625	0.063	B	26000	16000	703	31.8	76.6
514	0.052	302.5	300	B	0.061	22400	8250	421	40.9	110.5
598	0.065	218.5	163	B	0.090	12200	22000	306	35.9	110.6
689	0.067	131.3	127	B	0.040	5890	4250	208	25.9	120.4
780	0.090	110.5	118	B	0.272	7200	3000	78	14.8	68.1
878	0.012	90.3	71	0.023	0.230	9500	5000	192	30.6	94.6
969	0.040	79.3	68	B	1.100	9900	5500	175	29.4	74.9
1053	0.080	62.5	71	B	B	N	4750	145	27.0	86.3
1150	0.008	23.0	22	B	B	6930	3900	130	24.1	20.6
1235	0.010	35.0	39	B	0.090	7520	5000	113	9.2	40.9
1328	0.038	41.5	39	B	0.120	7600	4250	106	5.4	47.4
1415	0.018	36.3	12	B	0.060	8500	4500	87	4.6	53.0
1510	0.009	11.8	12	B	N	7290	3000	96	5.9	51.2

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-2. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (10) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	9.470	0.068	12.4	0.0	2550.0	0.055	0.354	467.50	45.500
331	7.080	0.053	7.3400	0.0	1350.0	0.016	0.013	213.50	20.700
437	0.800	0.125	6.6000	0.0	777.5	0.015	0.003	94.50	8.600
514	0.862	0.165	2.5500	B	712.5	0.030	B	70.75	7.225
598	0.482	0.175	1.4400	B	510.0	B	0.002	51.50	5.475
689	0.385	0.132	1.2750	B	390.0	B	B	38.25	4.575
780	0.150	0.112	0.9175	B	360.0	B	0.010	16.92	4.350
878	0.188	0.975	0.8520	B	312.5	0.002	B	27.75	4.400
969	0.177	0.105	0.6120	B	337.5	0.022	B	26.50	4.725
1053	0.060	0.097	0.5325	B	312.5	0.005	B	23.77	4.275
1150	0.150	0.040	0.7175	B	235.8	0.003	0.002	18.42	1.440
1235	0.258	0.110	0.8950	B	300.0	0.015	0.070	21.80	4.500
1328	0.085	0.098	0.5300	B	260.0	B	0.038	21.70	4.950
1415	0.070	0.090	0.3780	B	280.0	0.008	0.010	23.90	5.330
1510	B	0.031	0.2690	B	102.0	0.003	0.004	8.55	2.050

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.888	815.0	2230	0.170	0.730	71700	49500	1330	9.6	72.8
331	0.100	920.0	1023	0.063	1.100	38600	31000	1050	1.1	113.9
437	0.155	542.5	478	B	0.100	23700	17500	671	B	76.6
514	0.125	392.5	313	B	0.184	21800	9250	440	1.5	110.5
598	0.125	265.0	183	B	0.180	14000	26000	342	3.0	110.6
689	0.065	169.2	139	B	0.140	6500	4250	265	14.7	120.4
780	0.130	130.0	109	B	0.155	7400	1000	83	3.2	68.1
878	0.030	103.0	72	0.025	0.255	8650	4500	176	8.2	94.6
969	0.027	84.5	63	B	1.400	9600	5625	162	6.3	74.9
1053	0.107	70.0	71	B	N	N	5000	140	9.4	86.3
1150	0.019	25.0	18	B	0.088	6930	1770	119	8.0	20.6
1235	0.025	63.0	48	B	0.100	7240	N	119	10.4	40.9
1328	0.028	44.3	38	B	0.130	7550	3250	103	10.0	47.4
1415	0.055	45.5	39	B	0.030	9000	4380	105	8.3	53.0
1510	0.021	17.2	13	B	N	7880	3375	118	1.9	51.2

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-3. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED EPW (11) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	108.000	0.038	27.2	0.1	392.5	0.031	0.020	87.50	14.700
437	N	N	N	N	N	N	N	N	N
514	N	N	N	N	N	N	N	N	N
598	N	N	N	N	N	N	N	N	N
689	N	N	N	N	N	N	N	N	N
780	N	N	N	N	N	N	N	N	N
878	N	N	N	N	N	N	N	N	N
969	N	N	N	N	N	N	N	N	N
1053	N	N	N	N	N	N	N	N	N
1150	N	N	N	N	N	N	N	N	N
1235	N	N	N	N	N	N	N	N	N
1328	N	N	N	N	N	N	N	N	N
1415	N	N	N	N	N	N	N	N	N
1510	N	N	N	N	N	N	N	N	N

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	38.0
331	0.715	41.5	1275	0.140	19.000	32600	20500	344	3.9	294.1
437	N	N	N	N	N	N	N	N	N	280.2
514	N	N	N	N	N	N	N	N	N	355.5
598	N	N	N	N	N	N	N	N	N	347.1
689	N	N	N	N	N	N	N	N	N	376.0
780	N	N	N	N	N	N	N	N	N	254.0
878	N	N	N	N	N	N	N	N	N	261.5
969	N	N	N	N	N	N	N	N	N	94.6
1053	N	N	N	N	N	N	N	N	N	396.7
1150	N	N	N	N	N	N	N	N	N	251.5
1235	N	N	N	N	N	N	N	N	N	304.7
1328	N	N	N	N	N	N	N	N	N	225.0
1415	N	N	N	N	N	N	N	N	N	447.4
1510	N	N	N	N	N	N	N	N	N	337.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-4. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED EPW (11) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	1.680	0.115	14.2	B	1160.0	0.030	0.034	239.00	26.200
331	4.200	0.040	15	0.0	1230.0	0.016	B	252.50	25.000
437	0.460	0.065	11.8	B	927.5	0.025	B	194.30	17.600
514	0.277	0.010	5.0000	B	917.5	0.007	0.002	179.00	18.150
598	0.137	0.057	4.7000	B	860.0	0.002	B	153.50	16.400
689	0.105	B	5.1750	B	830.0	B	B	139.00	15.900
780	0.090	0.042	4.1250	B	820.0	B	0.015	67.20	14.300
878	0.184	0.032	4.4750	B	886.2	B	B	127.00	13.620
969	0.131	0.025	3.4250	B	867.5	0.012	B	103.30	12.130
1053	0.060	0.035	4.1000	B	870.0	0.005	0.030	109.75	14.550
1150	0.150	0.017	4.5000	B	615.0	0.002	0.038	72.75	3.720
1235	0.220	0.055	5.8000	B	843.0	0.853	1.270	111.00	12.100
1328	0.065	0.013	4.7300	B	675.0	B	0.090	94.00	10.600
1415	0.085	B	3.9500	B	720.0	0.008	0.010	105.00	11.200
1510	B	B	2.9000	B	286.0	0.002	0.014	40.30	4.790

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.730	1040.0	1210	0.135	0.360	40200	21000	1920	18.2	38.0
331	0.698	985.0	1295	0.145	0.700	40600	27000	1200	5.1	294.1
437	0.535	807.5	1025	0.093	0.180	27300	12000	N	N	280.2
514	0.547	677.5	1000	B	0.158	29800	19000	758	2.1	355.5
598	0.440	650.0	835	B	0.158	24600	14500	680	10.8	347.1
689	0.442	560.0	758	B	0.140	21200	10500	363	9.8	376.0
780	0.392	510.0	725	B	0.272	17150	5000	253	8.7	254.0
878	0.397	502.5	653	B	0.150	23400	20250	587	15.6	261.5
969	0.351	383.7	589	B	0.737	19590	11500	441	13.7	94.6
1053	0.345	350.0	600	B	B	19100	11500	212	3.7	396.7
1150	0.094	114.0	170	B	B	14000	9250	303	10.6	251.5
1235	0.315	378.0	620	B	N	20000	8750	491	11.1	304.7
1328	0.180	335.0	540	B	0.140	16300	N	409	7.7	225.0
1415	0.165	403.0	608	B	N	18200	10500	437	9.2	447.4
1510	0.035	185.0	240	B	N	27900	7000	560	1.5	337.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-5. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED CPB (12) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	N	N	N	N	N	N	N	N	N
437	N	N	N	N	N	N	N	N	N
514	N	N	N	N	N	N	N	N	N
598	N	N	N	N	N	N	N	N	N
689	N	N	N	N	N	N	N	N	N
780	N	N	N	N	N	N	N	N	N
878	N	N	N	N	N	N	N	N	N
969	N	N	N	N	N	N	N	N	N
1053	N	N	N	N	N	N	N	N	N
1150	N	N	N	N	N	N	N	N	N
1235	N	N	N	N	N	N	N	N	N
1328	N	N	N	N	N	N	N	N	N
1415	N	N	N	N	N	N	N	N	N
1510	N	N	N	N	N	N	N	N	N

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	107.0
331	N	N	N	N	N	N	N	N	N	252.4
437	N	N	N	N	N	N	N	N	N	289.4
514	N	N	N	N	N	N	N	N	N	429.9
598	N	N	N	N	N	N	N	N	N	431.6
689	N	N	N	N	N	N	N	N	N	360.4
780	N	N	N	N	N	N	N	N	N	298.8
878	N	N	N	N	N	N	N	N	N	309.6
969	N	N	N	N	N	N	N	N	N	115.4
1053	N	N	N	N	N	N	N	N	N	369.1
1150	N	N	N	N	N	N	N	N	N	260.4
1235	N	N	N	N	N	N	N	N	N	262.5
1328	N	N	N	N	N	N	N	N	N	190.8
1415	N	N	N	N	N	N	N	N	N	494.7
1510	N	N	N	N	N	N	N	N	N	327.5

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-6. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED CPB (12) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	2.650	0.128	23.9	0.0	1200.0	0.030	0.019	270.00	26.200
331	1.140	0.135	29.5	B	872.5	0.021	0.010	257.50	16.100
437	0.408	0.505	55.5	B	1225.0	0.015	B	390.00	17.600
514	1.145	0.155	27	B	1105.0	0.002	0.002	350.00	16.125
598	0.480	0.137	25.5	B	920.0	B	B	300.00	13.425
689	0.365	0.177	23.35	B	805.0	B	B	245.00	11.750
780	0.130	0.187	19.52	B	735.0	B	B	118.25	10.075
878	0.262	0.110	18.3	B	750.0	B	B	209.00	10.150
969	0.137	0.037	17.5	B	845.0	0.010	B	202.00	10.500
1053	0.082	0.057	16.25	B	780.0	B	0.012	172.50	13.000
1150	0.235	0.017	14.78	B	700.0	0.011	0.006	136.00	3.660
1235	0.218	0.073	15.4	B	805.0	0.050	0.375	150.00	10.700
1328	B	0.080	20.1	B	1030.0	B	0.010	196.00	15.100
1415	0.055	0.020	12.6	B	260.0	0.008	0.008	145.00	11.300
1510	B	B	9.4300	B	259.0	B	0.002	51.90	4.310

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.973	1162.5	1993	0.168	0.620	46500	32100	2280	12.9	107.0
331	0.353	782.5	3075	0.348	0.140	30100	18500	850	9.1	252.4
437	0.438	1007.5	5125	0.195	0.080	31600	11000	N	N	289.4
514	0.372	840.0	4525	0.035	0.189	32080	21500	896	3.8	429.9
598	0.290	725.0	4075	B	0.248	27300	23000	654	5.5	431.6
689	0.255	547.5	2950	B	0.120	14830	10000	259	12.1	360.4
780	0.202	532.5	1563	B	0.349	18700	4000	230	3.0	298.8
878	0.247	505.0	2750	B	0.738	24100	9400	460	6.4	309.6
969	0.212	482.5	1410	B	0.700	22300	4500	531	5.8	115.4
1053	0.200	425.0	2365	B	N	18900	10200	492	5.8	369.1
1150	0.082	129.0	758	B	B	13700	12300	328	7.1	260.4
1235	0.190	350.0	1910	B	N	14800	9000	363	8.7	262.5
1328	0.173	458.0	2470	B	N	15700	N	371	7.7	190.8
1415	0.098	360.0	1810	B	0.060	16200	9300	368	5.5	494.7
1510	0.011	156.0	704	B	N	15400	7800	421	3.1	327.5

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-7. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED GES (13) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	3.830	B	19.9	B	845.0	0.025	0.034	196.00	15.300
331	1.480	B	19.8	B	910.0	0.009	0.008	181.50	14.300
437	0.398	B	19.9	0.0	970.0	0.015	B	189.50	13.700
514	0.770	B	10.025	B	1145.0	0.002	0.002	215.25	15.350
598	0.750	B	8.0000	B	855.0	B	0.017	142.25	10.050
689	0.217	0.122	7.0250	B	637.5	B	0.002	100.25	6.625
780	0.720	0.042	6.1250	B	610.0	B	0.022	49.75	4.100
878	3.120	B	5.4500	B	450.0	0.005	0.017	80.50	1.190
969	0.925	0.025	5.6250	B	405.0	0.010	B	69.75	2.625
1053	N	B	4.9250	B	352.5	B	0.007	52.50	1.432
1150	1.057	B	8.0000	B	340.0	0.004	0.007	60.50	0.432
1235	1.050	B	3.7800	B	206.0	0.020	0.035	26.00	0.750
1328	N	N	N	N	N	N	N	N	N
1415	N	N	N	N	N	N	N	N	N
1510	N	N	N	N	N	N	N	N	N

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.333	652.5	775	0.135	0.600	29200	26000	1400	25.4	197.0
331	0.300	565.0	680	0.163	0.340	26600	16000	742	19.7	265.4
437	0.318	517.5	953	0.075	0.230	30400	12500	N	N	393.6
514	0.485	822.5	1070	B	0.126	30300	18500	904	19.9	1288.5
598	0.205	515.0	553	B	0.271	13300	22000	502	15.1	1136.7
689	0.130	280.0	355	B	0.210	9900	5250	240	14.9	453.5
780	0.050	221.0	455	B	0.753	870	N	84	1.2	359.3
878	0.065	203.5	295	B	0.130	614	291	154	3.2	667.0
969	0.032	166.8	495	B	1.175	3020	740	159	13.7	202.5
1053	0.045	140.0	168	B	N	495	90	58	1.7	777.8
1150	0.019	58.0	85	B	0.750	723	N	91	2.4	360.7
1235	0.015	70.0	90	B	0.680	485	N	84	3.8	980.5
1328	N	N	N	N	N	N	N	N	N	246.5
1415	N	N	N	N	N	N	N	N	N	447.1
1510	N	N	N	N	N	N	N	N	N	297.0

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-8. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED GES (13) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	1.810	0.025	23.7	B	1375.0	0.028	0.012	300.00	27.200
331	2.050	B	20.6	0.0	1210.0	B	0.015	242.80	20.400
437	0.460	B	19	B	1000.0	0.015	B	201.30	15.100
514	0.405	B	9.8750	B	1070.0	0.007	0.002	202.50	13.725
598	0.452	0.102	6.2250	B	712.5	0.017	0.017	113.75	8.250
689	0.262	0.232	8.5500	B	725.0	B	B	129.25	7.450
780	0.335	0.032	5.3250	B	397.5	0.052	0.005	43.00	1.640
878	3.900	B	5.6500	B	257.5	B	0.002	77.50	0.185
969	0.225	B	4.6750	B	290.0	0.005	B	60.50	0.342
1053	0.187	B	5.3500	B	335.0	0.002	0.005	57.75	0.685
1150	1.932	B	8.0700	B	290.0	0.002	0.005	54.75	0.248
1235	0.775	B	6.4000	B	208.0	0.018	0.020	38.50	0.800
1328	B	B	7.9000	B	211.0	B	0.020	43.50	0.978
1415	B	B	6.3000	B	260.0	0.148	0.005	50.50	0.158
1510	B	0.008	3.3800	B	86.0	0.003	0.002	19.00	0.112

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.698	1235.0	1300	0.208	1.210	42750	42900	2500	25.4	197.0
331	0.345	757.5	970	0.220	0.520	34200	23000	876	3.5	265.4
437	0.303	750.0	895	0.155	0.300	29500	13500	N	N	393.6
514	0.315	737.5	885	B	0.147	22870	16500	823	1.3	1288.5
598	0.147	390.0	423	B	0.214	15700	21000	418	3.4	1136.7
689	0.077	307.5	360	B	0.380	5800	4500	338	4.8	453.5
780	0.077	208.8	273	B	0.524	1600	N	98	2.7	359.3
878	0.045	189.7	234	B	0.325	505	81	191	B	667.0
969	0.035	148.7	182	B	1.650	455	56	140	1.8	202.5
1053	0.037	135.0	163	B	N	465	56	51	1.2	777.8
1150	0.010	54.0	68	B	0.638	582	282	76	B	360.7
1235	0.025	103.0	97	B	0.460	315	190	64	1.1	980.5
1328	0.025	93.8	170	B	0.290	N	42	62	1.3	246.5
1415	0.030	84.5	105	B	0.640	400	30	N	N	447.1
1510	0.012	35.9	39	B	N	360	2	74	N	297.0

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-9. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED EPW (14) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	1.880	B	14.1	B	1180.0	0.026	0.010	238.50	18.700
437	0.458	B	10.5	B	875.0	0.033	B	169.00	12.600
514	0.187	B	4.1000	B	867.5	0.002	B	157.25	12.075
598	0.332	0.080	2.8250	B	822.5	B	0.017	108.25	9.800
689	0.275	0.150	3.0250	B	937.5	B	B	111.75	10.900
780	0.175	0.027	2.1250	B	915.0	0.020	0.007	52.00	9.150
878	0.317	B	2.4200	B	915.0	B	B	91.75	7.775
969	0.205	B	2.0175	B	907.5	0.022	B	89.00	8.375
1053	0.125	B	1.9700	B	772.5	0.005	0.005	77.75	9.350
1150	0.807	B	2.7250	B	687.5	0.002	0.028	76.50	3.280
1235	0.398	0.015	2.7500	B	700.0	0.013	0.193	77.00	7.950
1328	0.135	0.033	2.1800	B	605.0	B	0.093	63.50	7.980
1415	0.160	0.015	1.8530	B	593.0	0.015	B	65.80	7.900
1510	0.486	B	0.9220	B	162.0	0.008	0.012	20.20	2.080

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	89.0
331	0.685	972.5	1333	0.243	0.180	44800	31000	1550	20.0	429.3
437	0.518	957.5	1098	0.150	0.200	36520	12000	N	N	279.8
514	0.617	780.0	970	B	0.147	30800	17000	1050	28.0	385.4
598	0.415	555.0	650	B	0.209	23700	24500	701	25.7	417.1
689	0.395	490.0	598	B	0.080	23000	11000	527	24.4	460.3
780	0.317	435.0	548	B	0.310	16000	5500	233	11.5	323.7
878	0.315	350.0	450	B	0.150	9000	12000	331	17.0	331.1
969	0.282	332.5	465	B	1.250	20900	10250	468	24.1	115.1
1053	0.262	287.5	410	B	B	15900	10250	391	24.7	361.2
1150	0.080	114.0	156	B	B	16000	8250	379	19.2	209.3
1235	0.238	280.0	398	B	N	14200	13750	394	9.8	329.7
1328	0.173	231.0	360	B	N	8370	1750	313	4.0	97.7
1415	0.183	246.0	398	B	0.070	14400	9000	200	0.9	292.2
1510	0.049	70.7	122	B	N	6980	4125	188	6.1	361.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-10. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED EPW (14) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	8.450	B	22.2	0.0	1727.5	0.030	0.054	310.00	29.700
331	3.230	B	15.8	B	1535.0	0.009	0.020	287.50	25.000
437	0.743	B	11.2	B	947.5	0.015	0.003	192.80	14.400
514	0.820	B	4.6500	B	875.0	0.005	0.002	166.50	12.600
598	0.520	0.077	3.6750	B	920.0	B	0.002	156.25	14.000
689	0.855	0.090	4.0500	B	940.0	B	0.010	131.75	12.825
780	0.300	B	2.4675	B	867.5	0.010	0.007	98.75	9.800
878	0.307	B	2.4900	B	960.0	0.005	0.002	104.00	9.175
969	0.290	B	1.9975	B	945.0	0.022	B	91.50	8.625
1053	0.160	B	2.0700	B	872.5	0.002	0.007	90.25	10.350
1150	0.292	0.012	2.4325	B	652.5	0.002	0.005	70.75	3.100
1235	0.463	0.020	2.7500	B	553.0	0.018	0.053	60.50	6.480
1328	1.070	B	3.3800	B	693.0	B	0.065	82.50	8.130
1415	0.215	0.025	1.8700	B	605.0	0.008	0.015	67.30	8.280
1510	0.193	B	1.0200	B	156.0	0.005	0.005	20.30	2.350

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	1.210	1385.0	1895	0.278	N	57300	42000	2930	17.1	89.0
331	0.573	935.0	1578	0.105	0.680	50600	34000	1370	2.3	429.3
437	0.583	910.0	1203	0.148	0.220	38700	16500	N	N	279.8
514	0.612	872.5	1065	0.037	0.168	31480	19000	1150	3.9	385.4
598	0.535	800.0	908	B	0.237	30400	26000	982	2.1	417.1
689	0.502	630.0	730	B	0.120	23800	11000	599	4.1	460.3
780	0.377	455.0	578	B	0.349	18900	12000	246	1.0	323.7
878	0.372	410.0	490	B	0.200	17900	12500	531	2.7	331.1
969	0.345	332.5	473	B	0.475	18950	10000	459	2.1	115.1
1053	0.327	317.5	470	B	B	19100	16500	186	2.2	361.2
1150	0.088	106.0	147	B	B	14900	9000	352	3.4	209.3
1235	0.002	220.0	305	B	N	11400	8750	294	4.4	329.7
1328	0.173	303.0	443	B	N	13300	7250	402	4.5	97.7
1415	0.193	240.0	388	B	N	14400	9500	223	4.9	292.2
1510	0.054	67.8	127	B	N	12600	1875	207	5.1	361.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-11. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (15) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	2.000	B	8.0900	B	1067.5	0.030	0.082	177.80	18.400
331	1.690	B	7.0400	B	1117.5	0.004	0.020	156.80	18.600
437	0.598	0.038	6.0000	B	927.5	0.015	0.005	150.80	15.000
514	0.180	0.055	2.3225	B	652.5	0.002	0.002	132.00	12.650
598	0.265	0.135	1.4475	B	442.5	B	0.010	85.25	9.850
689	0.170	0.125	1.2300	B	352.5	B	B	62.25	8.600
780	0.122	B	1.1300	B	360.0	B	B	70.75	9.250
878	0.345	B	0.9400	B	315.0	0.002	0.007	55.25	7.250
969	0.215	B	0.7625	B	275.0	0.020	B	41.00	5.970
1053	0.232	B	1.1325	B	365.0	0.002	0.010	59.75	8.725
1150	0.227	B	1.7820	B	417.5	0.004	0.010	71.25	3.460
1235	0.368	0.280	0.1570	B	395.0	0.013	0.158	65.80	8.330
1328	0.140	0.023	1.3600	B	385.0	B	0.080	57.80	8.500
1415	0.220	0.020	1.5800	B	545.0	0.018	0.043	88.30	11.300
1510	0.115	0.007	0.8110	B	189.0	0.002	0.006	29.30	4.260

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.483	592.5	943	0.098	N	N	25000	800	23.4	234.4
331	0.463	615.0	838	0.108	0.220	32600	24500	881	21.3	259.6
437	0.413	585.0	90	0.160	B	32280	18000	844	27.7	274.9
514	0.415	562.5	760	0.050	0.084	32370	16000	838	29.2	410.8
598	0.237	360.0	428	B	0.158	16900	25000	575	31.4	374.0
689	0.175	272.5	298	B	0.070	9400	5750	405	21.0	382.0
780	0.175	287.5	383	B	0.349	11700	5250	201	14.0	282.7
878	0.167	210.5	226	B	0.130	11250	11500	385	25.5	326.0
969	0.077	142.7	169	B	0.150	9800	3500	280	18.5	256.2
1053	0.182	217.5	250	B	B	12900	6000	428	26.5	303.1
1150	0.072	114.0	138	B	B	13500	1020	492	19.8	252.4
1235	0.170	250.0	298	B	N	11400	N	472	23.2	225.5
1328	0.103	205.0	268	B	N	12800	6000	408	21.3	224.9
1415	0.193	370.0	448	B	0.090	19000	14400	618	18.5	357.1
1510	0.102	107.0	134	B	N	31500	5000	504	18.5	275.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-12. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (15) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	14.900	B	8.3400	0.0	1240.0	0.040	0.052	222.30	22.200
331	3.130	B	8.7400	0.0	1372.5	0.001	0.005	209.50	23.100
437	1.760	B	6.0300	B	950.0	0.013	0.003	136.80	14.500
514	1.092	B	2.3100	0.0	762.5	0.012	0.002	132.00	13.175
598	0.640	0.057	1.7575	B	542.5	B	B	111.75	11.600
689	0.420	0.140	1.9675	B	510.0	B	0.020	98.00	11.150
780	0.295	0.025	1.5000	B	412.5	0.017	B	84.25	10.550
878	0.330	B	1.8125	B	567.5	0.002	0.005	100.50	9.000
969	0.313	B	1.3000	B	485.0	0.030	B	86.75	9.725
1053	0.200	B	1.4100	B	562.5	0.005	0.007	94.25	13.900
1150	0.282	0.013	1.5300	B	337.5	0.001	0.004	59.00	2.940
1235	0.295	0.020	1.8900	B	428.0	B	0.020	72.50	10.200
1328	0.090	0.015	1.4900	B	370.0	B	0.050	61.80	9.580
1415	0.133	B	1.3900	B	555.0	0.005	B	89.00	12.700
1510	B	B	0.8400	B	180.0	0.002	0.004	28.20	4.370

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.403	695.0	1143	B	N	35700	32000	870	2.0	234.4
331	0.468	787.5	1088	0.053	0.500	36900	24500	966	B	259.6
437	0.378	590.0	803	0.125	0.200	66800	15500	811	2.1	274.9
514	0.347	545.0	775	0.035	0.189	26140	15000	827	4.4	410.8
598	0.262	500.0	613	B	0.496	22600	20000	779	B	374.0
689	0.262	410.0	505	B	0.120	16200	8500	651	3.0	382.0
780	0.227	357.5	470	B	0.349	15400	5500	255	2.7	282.7
878	0.265	405.0	480	B	0.235	16100	7000	587	2.4	326.0
969	0.230	312.5	423	B	0.775	18000	5500	589	4.5	256.2
1053	0.305	322.5	410	B	B	18400	10400	590	3.4	303.1
1150	0.076	93.0	113	B	B	16800	6000	403	4.0	252.4
1235	0.173	253.0	323	B	N	13100	9800	507	1.8	225.5
1328	0.070	237.0	293	B	N	13300	6250	490	4.9	224.9
1415	0.060	315.0	460	B	0.260	18400	12300	641	2.4	357.1
1510	0.019	116.0	132	B	N	14400	4500	543	N	275.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-13. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (16) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	6.080	B	8.2100	B	655.0	0.004	B	138.00	12.500
437	0.805	0.045	8.3800	B	672.5	0.013	0.003	148.80	11.000
514	0.605	0.030	4.0000	B	690.0	0.010	B	161.25	11.850
598	N	N	N	N	N	N	N	N	N
689	N	N	N	N	N	N	N	N	N
780	0.440	0.057	3.3000	B	672.5	B	0.010	165.50	14.200
878	N	N	N	N	N	N	N	N	N
969	N	N	N	N	N	N	N	N	N
1053	N	N	N	N	N	N	N	N	N
1150	N	N	N	N	N	N	N	N	N
1235	N	N	N	N	N	N	N	N	N
1328	N	N	N	N	N	N	N	N	N
1415	N	N	N	N	N	N	N	N	N
1510	N	N	N	N	N	N	N	N	N

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	156.1
331	0.268	357.5	713	0.078	2.120	34900	23000	711	13.6	235.0
437	0.308	605.0	928	0.083	0.140	25980	17000	887	17.0	274.5
514	0.340	690.0	N	0.052	0.255	25980	16000	902	13.0	376.5
598	N	N	N	N	N	29800	9500	N	N	428.6
689	N	N	N	N	0.150	38600	14000	801	9.6	354.8
780	0.365	693.0	937	B	N	30600	11000	N	N	342.9
878	N	N	N	N	N	N	N	N	N	312.7
969	N	N	N	N	N	N	N	N	N	173.7
1053	N	N	N	N	N	N	N	N	N	441.8
1150	N	N	N	N	N	N	N	N	N	251.0
1235	N	N	N	N	N	N	N	N	N	214.6
1328	N	N	N	N	N	N	N	N	N	248.4
1415	N	N	N	N	N	N	N	N	N	356.9
1510	N	N	N	N	N	N	N	N	N	330.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-14. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (16) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	31.800	0.043	14.8	0.0	1530.0	0.020	0.127	312.50	26.500
331	2.530	0.030	9.4900	B	1050.0	B	0.010	224.00	19.200
437	0.553	B	8.2000	B	857.5	0.010	0.003	175.50	14.000
514	0.265	B	3.5500	0.0	585.0	0.005	B	141.50	10.350
598	0.407	0.027	3.0000	0.0	475.0	B	0.002	120.25	9.550
689	0.380	0.132	2.9000	0.0	390.0	B	0.017	96.50	8.700
780	0.267	0.042	2.2400	0.0	327.5	0.012	B	80.75	7.400
878	0.395	0.047	2.0900	B	317.5	0.002	B	73.75	6.550
969	0.247	0.042	1.9400	B	500.0	0.037	0.005	103.75	7.870
1053	0.102	0.032	2.1825	B	365.0	0.002	0.007	75.00	8.025
1150	0.058	0.025	2.3700	B	297.5	N	0.004	61.00	2.130
1235	0.143	0.093	2.1100	B	325.0	0.010	0.070	59.30	5.730
1328	0.100	0.068	2.3480	B	320.0	0.005	0.090	67.80	6.700
1415	0.118	0.068	1.6500	B	403.0	0.008	0.030	80.00	7.950
1510	B	0.024	1.1400	B	206.0	0.002	0.011	40.80	3.700

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.638	1220.0	1575	B	8.120	76300	39500	1710	7.5	156.1
331	0.408	777.5	1198	0.065	0.400	37700	28000	966	2.3	235.0
437	0.240	602.5	1008	0.135	0.120	35100	23500	961	B	274.5
514	0.255	645.0	845	B	0.163	33500	50000	841	3.5	376.5
598	0.252	620.0	688	B	0.323	25400	6500	746	3.6	428.6
689	0.197	440.0	525	B	N	28300	9000	594	9.4	354.8
780	0.167	392.5	483	B	0.456	17500	6500	565	9.5	342.9
878	0.020	332.5	385	B	0.342	15600	9000	558	9.0	312.7
969	0.242	390.0	533	B	0.950	21700	13170	561	5.1	173.7
1053	0.212	332.5	375	B	B	16200	10000	520	5.3	447.8
1150	0.084	107.0	128	B	B	13800	10500	432	8.5	251.0
1235	0.155	250.0	298	B	0.130	11500	10000	N	N	214.6
1328	0.205	295.0	360	B	B	14200	8580	402	2.7	248.4
1415	0.213	290.0	433	B	N	16400	10200	547	7.8	356.9
1510	0.275	159.0	204	B	N	23000	2700	704	4.4	330.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-15. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED CPB (17) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	3.980	B	8.0600	B	867.5	0.010	0.022	169.00	17.900
331	1.720	B	8.7900	B	1022.5	0.001	0.008	175.00	18.000
437	0.625	B	7.3000	B	1025.0	0.023	0.003	163.00	14.500
514	0.370	B	3.4500	B	1082.5	B	B	164.75	14.200
598	0.235	0.057	3.3750	B	1052.5	0.007	0.007	147.75	13.975
689	0.460	B	2.8250	B	967.5	B	0.017	128.25	13.400
780	0.245	B	2.0500	B	897.5	0.042	B	111.50	12.800
878	0.292	0.025	2.0700	B	795.0	0.007	B	96.75	10.275
969	0.772	B	1.9025	B	907.5	0.052	0.022	108.00	10.025
1053	0.222	0.025	1.9800	B	867.5	0.007	0.010	102.75	9.800
1150	0.190	B	3.3750	B	915.0	0.005	0.012	133.80	4.240
1235	0.273	0.078	3.1300	B	735.0	0.250	0.235	108.00	9.700
1328	0.085	0.028	3.0000	B	875.0	B	0.118	130.00	11.700
1415	0.335	B	3.0000	B	958.0	0.015	0.005	185.00	14.100
1510	0.427	B	1.1600	B	303.0	0.017	0.009	56.30	3.170

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.383	810.0	3650	0.120	0.545	25400	26000	750	22.1	189.0
331	0.395	807.5	3275	0.220	0.187	30800	23000	910	20.6	218.8
437	0.380	877.5	3975	0.090	B	32930	14500	771	23.9	330.3
514	0.427	795.0	3675	0.045	B	32050	13000	814	17.8	362.3
598	0.410	827.5	3300	B	0.307	27500	19000	756	14.6	411.8
689	0.337	230.2	2775	B	B	30200	8000	671	2.4	294.7
780	0.225	550.0	3325	B	0.388	18400	7500	551	13.2	300.9
878	0.250	460.0	2137	B	N	16400	11500	491	15.5	297.1
969	0.250	487.5	3250	B	0.150	21400	10400	538	16.4	99.2
1053	0.267	485.0	3550	B	N	17900	15000	525	17.1	404.2
1150	0.124	244.0	1670	B	N	20500	20000	619	14.0	235.0
1235	0.240	505.0	3230	B	N	188	16000	563	13.5	334.6
1328	0.275	558.0	4730	B	N	N	12000	544	11.0	143.5
1415	0.303	933.0	6030	B	5.570	23000	18400	841	10.4	168.8
1510	0.017	288.0	2400	B	N	15100	6000	86	17.0	419.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-16. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED CPB (17) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	10.100	0.035	18.7	0.0	1502.5	0.033	0.114	290.00	24.100
331	1.460	0.038	6.6400	B	997.5	0.006	B	176.80	17.800
437	0.623	B	9.7800	0.0	1242.5	0.015	B	206.00	18.000
514	0.387	B	3.3750	B	1027.5	0.005	B	156.75	13.925
598	0.707	0.095	2.7000	B	972.5	0.007	0.007	126.00	12.825
689	0.372	0.095	2.3700	B	912.5	B	0.012	115.00	12.075
780	0.235	B	2.0275	B	867.5	0.007	B	104.25	11.300
878	0.247	B	1.7650	B	832.5	0.007	B	85.74	9.450
969	0.105	0.025	1.3220	B	855.0	0.037	B	88.25	8.750
1053	0.500	0.032	1.9600	B	915.0	0.037	0.020	112.25	10.175
1150	0.092	0.013	2.8200	B	805.0	0.005	0.005	110.00	3.720
1235	0.303	0.030	2.0900	B	650.0	0.015	0.103	76.30	8.200
1328	0.120	B	1.8550	B	675.0	B	0.020	97.30	8.980
1415	0.115	B	2.1500	B	778.0	0.010	0.003	127.00	11.100
1510	0.295	B	1.2200	B	334.0	0.013	0.005	59.20	3.390

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.670	1375.0	4700	0.150	0.757	56200	41000	1320	11.6	189.0
331	0.275	747.5	3225	0.228	0.112	N	22000	952	3.1	218.8
437	0.433	1007.5	3900	0.053	B	38800	20500	852	1.9	330.3
514	0.350	822.5	3825	B	B	29200	14000	742	3.9	362.3
598	0.292	752.5	3375	B	0.086	23000	14000	612	1.6	411.8
689	0.285	572.5	3050	B	B	27900	8000	508	25.2	294.7
780	0.237	540.0	3375	B	0.445	17600	9500	48	0.4	300.9
878	0.225	437.5	2875	B	N	15400	8000	386	4.1	297.1
969	0.227	427.5	3300	B	0.700	17800	11000	411	6.9	99.2
1053	0.270	495.0	3575	B	N	18500	13000	465	4.7	404.2
1150	0.110	208.0	1610	B	N	18400	25000	501	3.4	235.0
1235	0.250	355.0	3200	B	N	12500	8250	334	3.2	334.6
1328	B	420.0	3750	B	N	12850	9330	361	2.2	143.5
1415	0.053	740.0	4650	B	3.000	16600	11500	587	1.6	168.8
1510	0.013	288.0	2520	B	N	14000	10000	630	1.4	419.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-17. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED GES (18) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	5.300	0.045	15.7	0.0	1470.0	0.018	0.042	335.00	27.000
331	1.840	0.045	14.3	B	1395.0	0.006	0.008	282.50	26.000
437	0.695	B	10.08	B	1037.5	0.015	0.003	208.00	15.900
514	0.440	0.030	3.8250	B	940.0	0.005	B	182.00	13.200
598	0.200	0.097	2.9250	B	850.0	0.005	0.002	128.25	10.925
689	0.242	0.125	2.1775	B	765.0	B	0.007	95.50	9.450
780	0.297	0.040	1.6375	B	810.0	B	B	81.00	8.450
878	0.157	B	1.3125	B	855.0	0.002	B	66.25	8.000
969	0.192	B	1.3825	B	785.0	0.037	0.005	61.00	6.725
1053	0.160	B	1.1825	B	750.0	0.027	0.007	52.00	6.725
1150	0.069	B	1.5970	B	657.0	0.005	0.008	50.70	2.160
1235	0.220	B	1.5100	B	660.0	0.020	0.173	45.50	5.800
1328	0.105	0.015	0.9930	B	628.0	B	0.033	36.00	5.730
1415	0.370	B	0.7550	B	588.0	0.003	0.013	32.50	5.330
1510	B	B	B	B	581.0	B	0.006	B	B

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.713	1215.0	1633	0.090	0.502	46400	82000	1550	23.8	83.0
331	0.583	1115.0	1480	0.163	0.150	40400	29000	1480	23.8	294.5
437	0.375	907.5	1138	0.053	0.097	39700	28000	1020	23.0	633.1
514	0.297	797.5	905	0.035	0.163	33500	13500	883	25.5	679.9
598	0.222	572.5	540	B	0.123	23000	7500	614	28.4	622.3
689	0.170	552.5	345	B	0.090	24800	3500	408	11.8	488.4
780	0.150	249.2	298	B	0.581	15500	7500	316	22.9	357.3
878	0.150	211.3	440	B	0.202	17400	6000	256	N	488.6
969	0.067	181.7	278	B	0.300	15600	7750	244	27.1	234.7
1053	0.172	147.5	148	B	B	11900	9600	224	27.3	396.6
1150	0.055	61.0	154	B	B	12600	6600	188	22.6	306.0
1235	0.140	150.0	653	B	N	11400	6400	151	21.3	440.2
1328	0.048	82.3	83	B	N	11300	9900	93	22.8	211.4
1415	0.020	66.5	95	B	0.150	10000	6200	90	23.4	231.7
1510	B	B	B	B	N	10000	5000	64	2.2	392.6

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-18. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED GES (18) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	6.200	0.028	13.6	B	1180.0	0.030	0.029	285.00	25.500
331	2.550	0.033	12.9	0.0	1535.0	0.001	0.010	320.00	27.500
437	0.480	B	9.7000	0.0	1012.5	0.005	0.003	206.00	15.500
514	0.510	0.020	3.7750	B	907.5	0.005	B	175.00	11.575
598	0.305	0.137	2.6750	0.0	765.0	B	0.007	107.75	9.850
689	0.320	0.042	2.4250	B	810.0	B	B	97.75	9.800
780	1.135	0.050	1.8750	B	830.0	0.015	0.012	85.75	8.575
878	0.217	0.032	1.6750	B	860.0	B	B	73.25	8.475
969	0.210	0.027	1.9800	B	805.0	0.045	0.002	60.00	6.625
1053	0.160	0.050	1.3775	B	747.5	0.022	0.002	55.25	7.000
1150	0.067	0.021	1.6120	B	697.0	0.001	0.009	50.20	5.700
1235	0.310	0.030	1.6000	B	658.0	0.010	0.093	43.05	5.200
1328	0.230	0.055	1.2700	B	735.0	B	0.038	47.80	6.480
1415	0.215	0.053	1.1700	B	628.0	0.008	0.008	41.80	5.300
1510	0.104	0.017	0.6180	B	216.0	0.017	0.008	13.80	1.820

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.673	1147.5	1453	0.038	0.843	46500	79000	1560	14.8	83.0
331	0.608	1165.0	1705	0.145	0.327	42500	27500	1390	3.1	294.5
437	0.315	937.5	1135	0.088	0.280	38020	23500	1030	1.3	633.1
514	0.285	737.5	760	B	0.224	31260	12000	833	3.0	679.9
598	0.220	480.0	428	B	0.816	21500	14500	526	1.9	622.3
689	0.190	332.5	338	B	0.140	25200	6000	408	4.6	488.4
780	0.210	287.5	310	B	0.319	14400	11500	318	7.2	357.3
878	0.165	231.0	219	B	246	16350	7000	302	16.9	488.6
969	0.135	183.5	179	B	0.550	16400	8500	244	18.7	234.7
1053	0.257	155.0	146	B	B	12300	8700	183	19.1	396.6
1150	0.042	55.0	62	B	B	11800	6900	149	18.8	306.0
1235	0.045	110.0	139	B	N	10200	10500	127	18.3	440.2
1328	0.145	112.0	119	B	N	12100	9600	112	18.9	211.4
1415	0.055	102.0	116	B	1.580	10600	7000	106	19.6	231.7
1510	0.017	34.1	38	B	N	12100	6600	503	N	392.6

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-19. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED EPW (19) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	2.900	B	21.3	B	1465.0	0.009	B	330.00	16.100
437	1.310	B	20.2	B	1552.5	0.015	0.003	327.50	15.100
514	0.480	B	9.3750	B	1390.0	0.007	B	282.50	11.725
598	0.280	0.155	7.4750	B	1125.0	B	0.002	198.50	6.275
689	0.317	0.097	8.9250	B	1177.5	B	B	247.25	8.400
780	0.377	B	7.3500	B	1077.5	B	B	252.50	9.925
878	0.542	B	6.0750	B	247.3	0.010	0.017	142.00	1.165
969	0.909	B	6.6750	B	262.5	0.017	0.035	146.87	0.441
1053	0.972	B	5.9000	B	305.0	0.010	0.002	132.25	0.537
1150	1.010	B	12.5	B	277.0	0.024	0.005	147.00	0.822
1235	0.530	B	11.7	B	172.0	0.055	0.023	123.00	0.180
1328	B	B	9.9500	B	191.0	0.058	0.018	134.00	0.210
1415	1.040	B	5.2300	B	253.0	0.013	0.005	107.00	0.415
1510	B	B	4.5700	B	107.0	0.025	0.016	50.30	0.106

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	153.0
331	0.573	562.5	1328	0.068	0.598	28000	18500	711	8.2	316.0
437	0.465	620.0	1405	0.078	0.343	36650	23500	682	8.4	292.7
514	0.432	542.5	1080	0.060	0.490	28000	11500	696	10.7	349.5
598	0.275	402.5	763	B	0.209	13900	11000	470	3.0	366.1
689	0.300	352.5	840	B	0.465	22610	6000	570	2.1	352.0
780	0.272	477.5	978	B	0.365	22200	7500	493	6.2	313.0
878	0.177	330.0	675	B	N	2200	250	384	0.7	257.8
969	0.177	291.2	765	B	1.675	900	850	279	3.6	61.7
1053	0.180	260.0	700	B	N	1160	152	274	3.6	320.6
1150	0.365	88.0	410	B	1.000	N	180	238	5.6	280.4
1235	0.330	210.0	820	B	0.760	N	288	321	5.5	348.2
1328	0.213	221.0	810	B	0.150	594	67	N	2.4	287.1
1415	0.023	179.0	598	B	1.340	N	38	154	1.7	283.1
1510	0.213	87.9	313	B	N	880	28	201	N	348.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-20. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED EPW (19) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	2.900	B	39.2	0.0	1237.5	0.033	0.019	540.00	17.400
331	1.730	0.058	22.1	B	1395.0	B	B	365.00	15.600
437	0.233	B	20.2	0.0	1470.0	0.008	B	342.50	14.500
514	0.350	B	9.8750	0.0	1442.5	0.005	B	322.50	12.650
598	0.070	0.400	9.1250	0.0	1320.0	0.022	0.010	280.00	11.150
689	0.075	0.192	9.5750	B	1185.0	B	0.002	244.00	9.700
780	0.100	B	8.5000	0.0	1185.0	B	B	262.50	12.350
878	0.825	B	7.7750	B	777.5	0.007	0.010	207.50	7.670
969	0.932	0.052	7.0000	B	136.7	0.020	0.027	172.00	0.340
1053	0.662	B	7.0000	B	166.0	0.005	0.017	165.00	0.160
1150	0.369	0.022	11.7	B	162.0	0.063	0.005	152.00	0.240
1235	0.555	B	11.5	B	172.0	0.055	0.023	123.00	0.183
1328	B	B	8.5300	B	158.0	B	0.008	110.00	0.148
1415	0.130	B	6.1800	B	141.0	0.010	0.015	102.00	0.153
1510	B	B	3.1200	B	67.9	0.087	0.004	44.90	B

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	1.200	787.5	2180	B	0.493	31000	44000	1750	1.6	153.0
331	0.493	492.5	1355	0.163	0.224	27900	14500	655	1.1	316.0
437	0.360	580.0	1388	0.198	0.251	36160	24500	601	B	292.7
514	0.302	552.5	1140	B	0.204	28700	21000	665	1.9	349.5
598	0.287	547.5	1038	B	0.239	21500	14000	618	1.4	366.1
689	0.290	462.5	928	B	0.260	26660	8750	356	4.8	352.0
780	0.317	517.5	1075	B	0.353	20700	6500	556	1.5	313.0
878	0.262	407.5	994	B	N	14900	7000	565	3.6	257.8
969	0.260	330.0	958	B	2.450	2200	1000	510	6.9	61.7
1053	0.212	295.0	880	B	N	841	264	283	2.9	320.6
1150	0.237	110.0	390	B	1.280	1370	99	260	2.8	280.4
1235	0.255	150.0	795	B	1.020	N	306	235	2.9	348.2
1328	0.168	188.0	648	B	0.580	198	60	N	N	287.1
1415	0.168	176.0	720	B	0.810	300	57	181	1.9	283.1
1510	0.087	80.0	239	B	N	820	46	170	N	348.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-21. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED CPB (20) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	86.500	0.065	13.3	B	1462.5	0.058	0.879	420.00	30.700
331	24.100	0.115	9.4100	B	1465.0	0.301	0.065	440.00	25.000
437	14.600	N	9.5500	B	1442.5	0.155	0.033	485.00	23.200
514	1.490	B	3.8750	B	1435.0	0.045	0.005	455.00	19.425
598	N	N	N	N	N	N	N	N	N
689	1.115	0.132	2.5000	B	1477.5	B	B	204.00	13.200
780	0.205	B	2.4150	B	1752.5	B	B	231.00	17.650
878	2.625	B	2.5000	B	470.0	0.017	B	185.70	2.450
969	0.562	B	1.3270	B	88.7	0.012	0.005	140.00	0.120
1053	1.292	B	1.1300	B	98.2	0.017	0.017	131.25	0.187
1150	1.250	B	2.1200	B	117.0	0.009	0.005	123.00	0.282
1235	1.650	B	1.8400	B	116.0	0.003	0.020	112.00	0.250
1328	0.520	B	1.2500	B	114.0	0.013	0.015	96.80	0.258
1415	0.640	B	0.9330	B	133.0	0.015	0.013	91.00	0.330
1510	0.190	B	0.5040	B	37.8	0.009	0.016	33.50	0.094

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	1.140	1000.0	32750	0.780	7.430	35500	60000	900	11.9	155.0
331	1.020	962.5	22200	0.258	N	37200	19000	1090	18.7	313.4
437	0.810	1025.0	86000	0.193	N	37900	23000	844	17.0	423.1
514	0.770	970.0	80500	0.270	N	38000	18000	N	N	310.0
598	N	N	N	N	N	N	N	N	N	370.9
689	0.017	407.5	9025	B	N	24200	7000	615	2.2	388.6
780	0.157	445.0	9850	B	N	17500	4500	417	4.9	325.1
878	0.090	357.5	3975	B	0.881	11300	5000	392	2.7	244.5
969	0.010	295.0	5700	B	1.925	2000	750	320	5.4	93.5
1053	0.070	280.0	5325	B	N	1490	672	248	1.7	313.8
1150	0.025	101.0	1800	B	N	2650	222	206	3.0	205.9
1235	0.300	200.0	4100	B	N	N	108	637	15.2	304.2
1328	0.028	228.0	3600	B	N	1390	54	N	1.8	217.0
1415	0.015	208.0	3350	B	N	700	30	116	2.5	206.7
1510	0.009	80.8	1200	B	N	1220	51	95	N	300.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-22. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED CPB (20) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	17.100	0.223	7.9900	B	645.0	0.075	1.010	572.50	17.500
331	122.000	0.038	7.8100	B	1040.0	0.086	0.065	445.00	25.200
437	44.300	B	8.2000	B	1337.5	0.148	0.023	452.50	23.000
514	1.817	B	3.3250	B	1367.5	0.012	0.007	427.50	18.950
598	0.212	0.065	2.9000	B	1400.0	0.030	B	382.50	15.300
689	0.117	0.140	3.0000	B	1682.5	B	B	267.50	18.200
780	0.132	B	2.5000	B	1870.0	B	B	225.00	12.675
878	0.610	B	1.9000	B	115.7	0.010	B	159.00	0.220
969	0.147	0.112	1.3170	B	42.2	0.047	0.007	103.50	0.060
1053	0.340	0.075	1.0875	B	50.0	0.017	0.007	114.25	0.062
1150	0.228	0.025	1.9200	B	34.0	0.002	0.006	100.00	0.105
1235	1.000	0.045	1.8600	B	45.8	0.033	0.073	77.30	0.170
1328	0.675	0.033	1.5000	B	36.8	0.020	0.033	78.80	0.200
1415	0.263	B	0.8680	B	47.0	0.023	0.038	79.50	B
1510	0.151	0.012	0.6060	B	17.8	0.005	0.012	29.10	0.098

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.738	1015.0	77500	0.365	1.140	28700	49000	700	4.2	155.0
331	0.715	797.5	2700	0.390	5.500	31400	16000	737	4.4	313.4
437	0.700	965.0	111500	0.180	N	37830	28000	808	8.4	423.1
514	0.632	942.5	71500	0.197	N	37800	14000	948	11.6	310.0
598	0.370	807.5	25250	B	0.202	30260	7000	743	4.7	370.9
689	0.210	512.5	13825	B	N	63400	10500	708	0.3	388.6
780	0.025	432.5	10825	B	N	7600	4000	473	2.1	325.1
878	0.030	330.0	8150	B	0.205	4750	2500	303	1.7	244.5
969	0.035	245.5	6350	B	1.500	700	1250	335	1.9	93.5
1053	0.035	235.0	5550	B	N	1010	168	301	B	313.8
1150	0.040	93.0	1860	B	N	2550	136	224	4.4	205.9
1235	0.030	170.0	3580	B	N	N	180	223	3.7	304.2
1328	0.038	204.0	3500	B	0.350	1290	67	N	1.8	217.0
1415	0.023	179.0	2963	B	0.940	100	82	139	1.5	206.7
1510	0.020	72.4	1210	B	N	1220	144	293	N	300.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-23. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED GES (21) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	3.180	B	15.2	B	1230.0	B	B	417.50	20.700
437	1.010	B	8.6000	B	720.0	0.018	B	372.50	8.180
514	0.730	0.102	3.4000	B	285.0	0.017	B	372.50	1.050
598	0.740	0.042	2.8500	B	290.0	B	0.025	325.00	1.300
689	0.365	0.042	1.8000	B	245.2	B	0.020	255.00	0.750
780	1.460	B	1.3625	B	209.2	0.012	0.047	228.25	0.450
878	1.190	B	1.3100	B	165.5	0.010	0.030	188.00	0.310
969	0.377	B	1.1100	B	155.8	0.007	0.007	182.50	0.330
1053	0.380	B	1.0300	B	173.2	B	0.005	180.25	0.327
1150	0.353	B	1.5200	B	124.0	0.001	0.004	161.00	217
1235	0.408	B	1.5000	B	124.0	0.008	0.003	157.00	0.170
1328	0.155	B	1.6000	B	105.0	0.020	0.018	165.00	0.145
1415	N	N	N	N	N	N	N	N	N
1510	0.112	B	0.4790	B	47.0	B	0.004	50.30	0.090

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	137.0
331	0.430	767.5	1413	0.265	N	33300	20000	1020	12.8	202.9
437	0.193	537.5	763	0.093	N	20280	19000	616	10.6	372.6
514	0.152	522.5	1300	B	1.040	6370	N	646	10.6	358.5
598	0.042	512.5	620	B	0.963	900	110	369	5.3	372.8
689	0.020	362.5	515	B	1.040	2580	48	285	0.7	309.5
780	0.045	315.0	448	B	N	840	81	227	3.3	445.5
878	0.032	287.5	698	B	0.930	685	33	444	2.8	707.8
969	0.045	260.0	353	B	2.300	505	24	305	2.2	205.1
1053	0.052	247.5	283	B	N	384	N	289	1.0	492.8
1150	0.040	91.0	259	B	2.020	372	36	314	B	241.8
1235	0.068	160.0	305	B	1.890	N	21	331	1.4	379.7
1328	1.038	255.0	303	B	1.110	366	41	18	N	267.5
1415	N	N	N	N	1.480	320	33	326	1.3	188.9
1510	0.008	66.8	69	B	N	284	56	127	N	273.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-24. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED GES (21) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	3.400	0.038	17.4	0.0	937.5	0.008	0.004	437.50	16.700
331	3.550	0.045	12.5	0.0	1127.5	B	0.003	482.50	16.200
437	0.570	B	11.2	0.0	1067.5	0.008	B	440.00	15.600
514	0.882	0.180	2.7750	B	182.0	0.007	B	317.50	1.200
598	0.302	0.110	2.1200	B	145.0	0.007	0.005	317.50	0.385
689	0.212	0.062	1.9950	B	159.5	0.005	0.010	260.00	0.320
780	N	N	N	N	N	N	N	N	N
878	0.092	B	1.4820	B	87.2	0.007	B	185.75	0.090
969	0.110	B	1.1520	B	123.7	0.007	0.007	187.00	0.065
1053	0.092	B	1.0000	B	113.5	0.002	0.005	199.75	0.040
1150	0.075	B	1.6400	B	86.0	0.001	0.001	161.00	0.075
1235	0.103	0.028	1.7600	B	81.8	0.013	0.005	148.00	0.060
1328	0.115	0.015	1.3700	B	77.3	0.015	0.020	155.00	0.063
1415	0.800	B	1.0000	B	117.0	0.028	0.008	145.00	0.250
1510	B	0.010	0.5460	B	26.0	B	0.001	52.30	B

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.375	705.0	1385	0.030	2.690	30900	58000	840	5.4	137.0
331	0.320	707.5	1848	0.075	N	30900	18000	947	B	202.9
437	0.300	620.0	953	0.103	N	34000	18500	719	B	372.6
514	0.050	415.0	690	B	1.270	6000	N	512	4.2	358.5
598	0.042	410.0	590	B	1.360	6000	100	391	3.0	372.8
689	0.020	385.0	473	B	1.110	2740	13	711	2.0	309.5
780	N	N	N	N	N	270	10	213	1.4	445.5
878	0.020	312.5	338	B	1.390	560	24	231	4.2	707.8
969	0.027	272.5	315	B	2.750	235	47	282	1.0	205.1
1053	0.035	282.5	318	B	N	376	N	109	7.1	492.8
1150	0.030	101.0	111	B	1.320	246	50	307	B	241.8
1235	0.045	170.0	268	B	1.470	388	48	313	N	379.7
1328	0.038	225.0	405	B	1.220	347	55	68	N	267.5
1415	0.028	201.0	260	B	1.450	276	58	334	1.6	188.9
1510	0.007	80.4	79	B	N	272	54	303	N	273.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-25. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (22) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	N	N	N	N	N	N	N	N	N
331	N	N	N	N	N	N	N	N	N
437	N	N	N	N	N	N	N	N	N
514	N	N	N	N	N	N	N	N	N
598	N	N	N	N	N	N	N	N	N
689	N	N	N	N	N	N	N	N	N
780	N	N	N	N	N	N	N	N	N
878	N	N	N	N	N	N	N	N	N
969	N	N	N	N	N	N	N	N	N
1053	N	N	N	N	N	N	N	N	N
1150	0.265	N	0.4970	N	342.0	N	N	20.40	N
1235	N	N	N	N	N	N	N	N	N
1328	N	N	N	N	N	N	N	N	N
1415	N	N	N	N	N	N	N	N	N
1510	N	N	N	N	N	N	N	N	N

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	N	N	N	N	N	N	N	N	N	76.0
331	N	N	N	N	N	N	N	N	N	92.7
437	N	N	N	N	N	N	N	N	N	88.7
514	N	N	N	N	N	17620	8500	542	38.1	106.5
598	N	N	N	N	N	N	N	N	N	103.7
689	N	N	N	N	N	N	N	N	N	129.5
780	N	N	N	N	N	N	N	N	N	65.1
878	N	N	N	N	N	N	N	N	N	87.0
969	N	N	N	N	N	N	N	N	N	63.2
1053	N	N	N	N	N	N	N	N	N	132.5
1150	N	N	N	N	N	N	N	N	N	65.1
1235	N	N	N	N	N	N	N	N	N	59.4
1328	N	N	N	N	N	N	N	N	N	38.5
1415	N	N	N	N	N	N	N	N	N	96.9
1510	N	N	N	N	N	N	N	N	N	67.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE C-26. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (22) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	ALUMINUM	ARSENIC	BORON	BERYLLIUM	CALCIUM	COPPER	LEAD	MAGNESIUM	MANGANESE
247	3.450	B	12.3	0.0	1082.5	0.053	0.039	198.30	19.400
331	1.560	B	12.3	0.0	940.0	B	0.003	151.30	14.500
437	0.933	B	8.4000	B	570.0	0.015	0.013	92.30	7.150
514	0.527	B	2.4125	B	402.5	0.007	B	63.00	5.275
598	0.222	0.035	1.6000	B	330.0	B	B	45.25	4.400
689	0.257	B	1.1450	B	305.0	B	B	36.25	4.250
780	0.272	0.035	0.8025	B	337.5	B	0.012	32.75	4.100
878	0.214	0.040	0.6012	B	385.0	B	B	29.50	3.850
969	0.190	0.027	0.4262	B	422.5	0.015	B	29.25	3.937
1053	0.152	0.040	0.4400	B	427.5	0.005	0.005	27.50	4.150
1150	N	0.022	N	B	N	B	0.001	N	1.300
1235	0.488	0.050	0.6900	B	383.0	B	0.025	31.30	4.730
1328	0.160	0.063	0.2880	B	370.0	0.003	0.033	19.60	3.730
1415	0.135	0.063	0.2100	B	423.0	0.005	0.005	20.50	3.880
1510	B	0.027	0.1830	B	158.0	0.006	0.002	7.98	1.760

DAYS	NICKEL	POTASSIUM	SODIUM	SELENIUM	FLUORIDE	COD	BOD	TKN	PHOS	VOLUME
247	0.443	847.5	1015	0.040	0.330	27500	22000	670	1.7	76.0
331	0.443	820.0	800	B	0.200	28300	20000	1140	1.3	92.7
437	0.293	525.0	488	B	0.110	59800	14000	631	B	88.7
514	0.175	330.0	280	B	0.178	15150	8500	466	3.0	106.5
598	0.150	250.0	160	B	0.496	10700	31000	350	B	103.7
689	0.152	161.0	113	B	0.130	5500	3950	238	5.2	129.5
780	0.075	114.5	110	B	0.543	6200	2250	83	B	65.1
878	0.047	76.0	50	B	0.200	7650	4500	136	7.8	87.0
969	0.067	63.0	45	B	0.787	7150	1500	116	4.6	63.2
1053	0.097	55.0	39	B	N	N	4200	309	2.2	132.5
1150	0.024	16.0	10	B	0.100	5600	1500	79	11.5	65.1
1235	0.128	90.0	90	B	N	6270	6000	172	9.9	59.4
1328	0.068	25.0	22	B	N	6470	1400	48	15.9	38.5
1415	0.083	24.9	20	B	0.080	6800	4100	65	14.8	96.9
1510	0.027	10.0	7	B	N	6660	3100	65	8.7	67.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

APPENDIX D

LEVELS OF PARAMETERS TAKEN MONTHLY FROM TEST CELLS CONTAINING MSW ONLY FOR ABOVE-SOIL AND BELOW-SOIL LEACHATE SAMPLES

TABLE D-1. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (10) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0047	0.053	0.0008	317.5	32.50	N	11000	24500	24500	N	N	72.8
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0023	0.243	0.0005	305.0	29.00	1295	9000	N	N	4150	5.45	59.8
331	0.0189	0.194	0.0013	230.3	22.30	1158	8500	12000	12000	3800	5.30	0.0
359	0.0003	0.184	B	247.3	23.60	1015	9500	N	N	3600	5.30	54.1
388	0.0010	0.140	B	236.8	19.30	969	9500	10600	10600	2980	5.20	39.9
437	0.0053	0.130	0.0043	241.8	17.30	1090	6800	8500	8500	2330	5.15	36.7
458	0.0003	0.085	0.0008	229.5	12.80	461	7300	6400	6400	2000	5.05	0.0
486	B	0.041	B	267.5	10.70	384	7500	N	N	900	4.90	33.3
514	0.0010	0.032	0.0008	280.0	11.05	331	6000	4000	4000	1300	4.90	42.0
542	0.0010	0.100	N	320.0	9.92	298	5000	4600	4600	1810	5.15	35.0
570	0.0045	0.032	B	285.0	8.52	219	3500	4100	4100	1925	5.20	34.1
598	0.0002	0.017	0.0005	305.0	7.30	223	4000	5200	5200	1300	5.15	33.7
633	0.0010	0.020	B	322.5	6.67	184	4200	3750	3750	1600	5.15	42.8
664	0.0075	0.012	0.0015	352.5	6.25	125	3300	3520	3520	650	4.50	39.0
689	B	0.017	B	330.0	6.80	150	2800	3450	3450	650	4.80	40.1
724	B	0.012	B	357.5	5.75	120	2500	4100	4100	600	4.50	41.3
752	0.0037	0.012	0.0008	347.5	4.95	120	2500	3300	3300	550	4.90	15.1
780	0.0015	0.012	B	377.5	5.40	N	2200	6600	6600	350	4.90	24.6
815	B	0.022	N	380.0	4.85	N	3000	2000	2000	184	4.80	28.4
843	0.0017	0.032	B	382.5	5.15	386	3300	3280	3280	820	5.20	31.8
878	0.0002	0.027	B	420.0	4.88	N	3300	3080	3080	2130	5.20	35.2
906	0.0005	0.035	B	455.0	4.42	201	2700	3040	3040	1920	5.70	27.6
934	B	0.047	B	460.0	4.50	252	2600	3460	3460	1860	5.00	29.9
969	0.0017	0.012	B	480.0	4.60	100	2800	2750	2750	639	4.90	45.0
1053	0.0002	0.042	B	407.5	3.87	70	2500	2300	2300	1400	5.10	86.3
1150	0.0094	0.003	B	432.5	3.22	76	3000	1900	1900	2060	5.05	20.6
1235	0.0015	0.005	B	650.0	0.28	81	2900	2100	2100	1450	5.60	40.9
1328	0.0010	0.008	B	1090.0	0.28	N	3000	2640	2640	1600	5.70	47.4
1415	0.0015	0.010	B	1110.0	0.19	110	3000	2915	2915	1650	5.80	53.0
1510	0.0006	0.002	B	372.0	0.14	71	3000	N	N	1600	5.70	51.2

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-2. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (10) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.1297	1.800	0.0070	747.5	59.50	N	12000	25500	25500	N	N	72.8
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0563	0.588	0.0088	517.5	73.50	1854	9000	N	N	2530	5.00	59.8
331	0.0131	0.131	0.0020	477.5	23.10	1244	4100	11000	11000	3600	5.25	0.0
359	0.0033	0.182	0.0020	502.5	29.50	1149	10500	N	N	4150	5.40	54.1
388	0.0090	0.100	B	402.5	18.20	959	9000	9450	9450	3450	5.30	39.9
437	0.0130	0.053	0.0050	300.0	14.90	1037	6400	8000	8000	2640	5.25	36.7
458	0.0068	0.058	B	327.5	16.50	493	7800	6100	6100	1600	5.15	0.0
486	B	0.041	B	342.5	17.60	437	6500	N	N	1400	5.00	33.3
514	0.0045	0.030	B	325.0	16.40	341	6000	3500	3500	1275	5.10	42.0
542	0.0057	0.082	N	315.0	14.10	289	5000	4550	4550	1825	5.20	35.0
570	0.0032	0.045	B	335.0	13.17	246	3200	4800	4800	1725	5.20	34.1
598	0.0015	0.032	0.0005	330.0	12.17	226	4000	6200	6200	1500	5.15	33.7
633	0.0030	0.025	B	310.0	11.10	190	3500	4100	4100	1350	5.20	42.8
664	B	0.015	0.0013	307.5	7.75	162	3200	3420	3420	610	4.70	39.0
689	B	0.022	B	312.5	9.70	148	3000	3530	3530	900	4.90	40.1
724	B	0.012	B	340.0	7.95	120	2600	4300	4300	300	4.70	41.3
752	B	0.005	B	136.0	3.18	123	2700	3600	3600	600	4.90	15.1
780	0.0012	0.015	B	385.0	6.52	120	2600	3300	3300	400	5.00	24.6
815	0.0150	0.025	N	427.5	5.87	105	3000	2700	2700	580	4.85	28.4
843	0.0020	0.045	B	380.0	5.25	106	3300	2950	2950	1090	5.10	31.8
878	0.0005	0.035	B	445.0	5.07	N	3200	2900	2900	2340	4.50	35.2
906	0.0012	0.037	B	477.5	4.65	100	2700	2880	2880	2020	5.80	27.6
934	0.0005	0.032	B	455.0	4.60	N	2700	3380	3380	1970	4.90	29.9
969	0.0017	0.012	B	622.5	5.25	100	2900	3110	3110	852	5.00	45.0
1053	0.0005	0.145	B	455.0	4.75	124	2500	2500	2500	1550	5.30	86.3
1150	0.0008	0.005	B	490.0	3.25	N	3000	1600	1600	1160	5.05	20.6
1235	0.0065	0.230	B	298.0	2.88	101	2300	1900	1900	1200	5.30	40.9
1328	0.0005	0.008	B	825.0	1.47	N	2700	2350	2350	1200	5.40	47.4
1415	0.0015	0.008	B	835.0	3.25	79	2700	2850	2850	1200	5.50	53.0
1510	0.0012	B	B	328.0	1.14	91	2700	N	N	1200	5.40	51.2

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-3. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED EPW (11) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	38.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	N	N	B	N	N	N	N	N	N	N	N	86.7
331	0.0534	0.106	0.0013	23.4	7.30	1982	2700	8800	8800	N	3.90	0.0
359	0.0491	0.079	0.0010	21.6	5.70	1613	60000	N	N	N	4.20	207.4
388	N	N	B	N	N	N	N	N	N	N	N	134.9
437	N	N	B	N	N	N	N	N	N	N	N	145.3
458	N	N	B	N	N	N	N	N	N	N	N	0.0
486	N	N	B	N	N	N	N	N	N	N	N	138.6
514	N	N	B	N	N	N	N	N	N	N	N	105.2
542	N	N	B	N	N	N	N	N	N	N	N	111.7
570	N	N	B	N	N	N	N	N	N	N	N	111.3
598	N	N	B	N	N	N	N	N	N	N	N	128.7
633	N	N	B	N	N	N	N	N	N	N	N	107.1
664	N	N	B	N	N	N	N	N	N	N	N	145.3
689	N	N	B	N	N	N	N	N	N	N	N	136.2
724	N	N	B	N	N	N	N	N	N	N	N	94.5
752	N	N	B	N	N	N	N	N	N	N	N	53.4
780	N	N	B	N	N	N	N	N	N	N	N	85.5
815	N	N	B	N	N	N	N	N	N	N	N	115.1
843	N	N	B	N	N	N	N	N	N	N	N	64.0
878	N	N	B	N	N	N	N	N	N	N	N	87.4
906	N	N	B	N	N	N	N	N	N	N	N	110.1
934	N	N	B	N	N	N	N	N	N	N	N	94.6
969	N	N	B	N	N	N	N	N	N	N	N	0.0
1053	N	N	B	N	N	N	N	N	N	N	N	396.7
1150	N	N	B	N	N	N	N	N	N	N	N	251.5
1235	N	N	N	N	N	N	N	N	N	N	N	304.7
1328	N	N	N	N	N	N	N	N	N	N	N	225.0
1415	N	N	N	N	N	N	N	N	N	N	N	447.4
1510	N	N	N	N	N	N	N	N	N	N	N	337.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-4. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED EPW (11) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.1087	0.028	0.0015	240.0	38.80	N	11000	13000	13000	N	N	38.0
282	0.0078	0.900	0.0013	294.8	33.00	1310	11200	N	N	4070	5.30	0.0
303	0.0118	0.101	0.0075	295.0	27.80	1319	10500	N	N	3700	5.35	86.7
331	0.0224	0.094	0.0018	285.0	27.00	1552	8000	10800	10800	4200	4.20	0.0
359	0.0158	0.154	0.0008	272.5	47.50	1347	10000	N	N	3680	5.40	207.4
388	0.0078	0.125	B	290.0	12.30	1123	7000	9400	9400	3680	5.30	134.9
437	0.0315	0.170	0.0035	297.5	15.10	1087	8100	11400	11400	3120	5.40	145.3
458	0.0058	0.090	0.0010	320.0	14.20	1038	8000	8550	8550	2700	5.30	0.0
486	B	0.114	B	285.0	9.00	1019	7500	N	N	2200	5.20	138.6
514	0.0022	0.037	B	377.5	9.82	1036	10000	8100	8100	2225	5.15	105.2
542	0.0040	0.072	N	397.5	7.97	1000	8300	8100	8100	3275	5.35	111.7
570	0.0022	0.027	B	332.5	8.70	696	5500	9800	9800	2750	5.20	111.3
598	0.0097	0.040	0.0010	340.0	9.85	823	7200	11700	11700	2800	5.25	128.7
633	0.0045	0.035	B	327.5	9.22	745	10000	7800	7800	2700	5.25	107.1
664	0.0042	0.045	0.0013	335.0	9.97	789	2400	8400	8400	2500	4.80	145.3
689	0.0025	0.065	B	312.5	10.15	895	7300	7400	7400	1500	5.10	136.2
724	0.0005	0.040	B	327.5	27.00	600	6000	8200	8200	1800	5.10	94.5
752	0.0052	0.037	B	337.5	7.50	595	6500	9900	9900	1750	5.10	53.4
780	0.0022	0.047	B	375.0	9.42	618	6200	8000	8000	1550	4.85	85.5
815	0.0022	0.065	N	372.5	9.05	645	6100	7200	7200	1760	5.10	115.1
843	0.0027	0.035	B	377.5	8.75	882	7500	6850	6850	2740	5.70	64.0
878	0.0030	0.050	B	407.5	10.92	595	7500	7180	7180	5210	5.70	87.4
906	0.0017	0.122	B	435.0	8.25	550	7700	7510	7510	4680	5.80	110.1
934	0.0010	0.057	B	440.0	8.55	520	7000	7300	7300	5010	5.60	94.6
969	0.0020	0.047	B	448.7	11.38	510	7100	6100	6100	1750	5.10	0.0
1053	0.0007	0.037	B	475.0	10.97	520	6900	6400	6400	3750	5.20	396.7
1150	0.0011	0.009	B	479.5	5.75	350	6000	3800	3800	2890	5.05	251.5
1235	0.0055	0.170	B	613.0	6.95	548	7800	5825	5825	3050	5.20	304.7
1328	0.0028	0.075	B	338.0	B	478	6600	5280	5280	2550	5.40	225.0
1415	0.0005	0.043	B	458.0	0.18	430	6600	5580	5580	2555	5.45	447.4
1510	0.0007	0.011	B	196.0	0.20	522	6600	N	N	2550	5.40	337.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-5. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED CPB (12) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	107.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	N	N	B	N	N	N	N	N	N	N	N	119.2
331	N	N	B	N	N	N	N	N	N	N	N	0.0
359	N	N	B	N	N	N	N	N	N	N	N	133.2
388	N	N	B	N	N	N	N	N	N	N	N	135.7
437	N	N	B	N	N	N	N	N	N	N	N	153.7
458	N	N	B	N	N	N	N	N	N	N	N	0.0
486	N	N	B	N	N	N	N	N	N	N	N	146.9
514	N	N	B	N	N	N	N	N	N	N	N	143.9
542	N	N	B	N	N	N	N	N	N	N	N	169.4
570	N	N	B	N	N	N	N	N	N	N	N	134.8
598	N	N	B	N	N	N	N	N	N	N	N	136.3
633	N	N	B	N	N	N	N	N	N	N	N	160.5
664	N	N	B	N	N	N	N	N	N	N	N	106.7
689	N	N	B	N	N	N	N	N	N	N	N	119.0
724	N	N	B	N	N	N	N	N	N	N	N	134.7
752	N	N	B	N	N	N	N	N	N	N	N	127.4
780	N	N	B	N	N	N	N	N	N	N	N	105.9
815	N	N	B	N	N	N	N	N	N	N	N	65.5
843	N	N	B	N	N	N	N	N	N	N	N	103.7
878	N	N	B	N	N	N	N	N	N	N	N	95.4
906	N	N	B	N	N	N	N	N	N	N	N	110.5
934	N	N	B	N	N	N	N	N	N	N	N	115.4
969	N	N	B	N	N	N	N	N	N	N	N	0.0
1053	N	N	B	N	N	N	N	N	N	N	N	369.1
1150	N	N	B	N	N	N	N	N	N	N	N	260.4
1235	N	N	N	N	N	N	N	N	N	N	N	262.5
1328	N	N	N	N	N	N	N	N	N	N	N	190.8
1415	N	N	N	N	N	N	N	N	N	N	N	494.7
1510	N	N	N	N	N	N	N	N	N	N	N	327.5

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-6. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS
CONTAINING MSW AND PROCESS B TREATED CPB (12) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0057	0.221	0.0015	347.5	24.80	N	13500	17500	17500	N	N	107.0
282	0.0085	0.060	0.0090	210.3	9.68	4184	15000	N	N	2960	5.10	0.0
303	0.0020	0.051	0.0015	198.8	11.60	3761	13000	N	N	2575	5.40	119.2
331	0.0241	0.109	0.0023	188.0	8.50	4598	12000	7800	7800	3000	5.50	0.0
359	0.0046	0.584	0.0008	213.8	11.50	4407	15000	N	N	3250	5.40	133.2
388	0.0030	0.568	B	212.0	9.58	4917	14000	9750	9750	3350	5.50	135.7
437	0.0098	0.533	0.0048	272.5	14.90	5185	15500	12800	12800	3370	5.45	153.7
458	0.0043	0.500	0.0008	267.5	15.00	6169	13000	10100	10100	3100	5.35	0.0
486	B	0.358	0.0008	267.5	11.10	6685	12000	N	N	2650	5.30	146.9
514	0.0095	0.287	B	315.0	12.60	6006	17000	8000	8000	N	5.00	143.9
542	0.0042	0.212	N	327.5	8.25	6288	16700	8200	8200	3675	5.55	169.4
570	0.0030	0.337	0.0035	302.5	14.20	6273	12400	11100	11100	3900	5.45	134.8
598	0.0030	0.205	0.0005	327.5	12.67	5549	14000	10000	10000	2750	5.55	136.3
633	N	0.172	B	325.0	10.95	N	13000	7770	7770	3200	5.40	160.5
664	0.0012	0.170	0.0013	385.0	10.30	4669	12000	8620	8620	2500	5.00	106.7
689	B	0.137	B	337.5	9.90	5680	12500	7050	7050	1350	5.15	119.0
724	B	0.175	B	477.5	7.35	4750	10800	8000	8000	2600	5.20	134.7
752	0.0010	0.155	0.0130	485.0	6.17	4680	16000	7700	7700	1500	5.40	127.4
780	0.0010	0.067	B	372.5	4.82	4084	12000	8100	8100	1550	5.30	105.9
815	B	0.087	N	340.0	3.30	4665	12000	6800	6800	1720	5.20	65.5
843	0.0012	0.087	B	385.0	2.77	4294	15000	6650	6650	3030	5.70	103.7
878	0.0015	0.050	B	350.0	3.10	4328	16000	6150	6150	5750	6.00	95.4
906	0.0005	0.107	B	457.5	1.88	3830	14200	7120	7120	5160	6.10	110.5
934	B	0.045	B	465.0	0.88	3435	12000	6900	6900	4790	5.80	115.4
969	0.0005	0.052	B	452.5	1.47	4070	15000	5420	5420	2440	5.50	0.0
1053	0.0007	0.067	B	475.0	0.47	3030	12000	5600	5600	3750	5.50	369.1
1150	0.0012	0.006	B	51.8	0.99	180	12000	3700	3700	3470	5.40	260.4
1235	0.0060	0.040	B	613.0	1.16	2810	1080	4700	4700	2800	5.55	262.5
1328	0.0050	0.028	B	873.0	0.10	N	11000	3130	3130	2500	5.65	190.8
1415	0.0008	0.020	B	740.0	0.18	470	11000	5250	5250	2500	5.50	494.7
1510	0.0002	0.007	B	279.0	0.13	654	11000	N	N	2500	5.65	327.5

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-7. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED GES (13) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0102	0.015	0.0023	167.3	12.20	N	8500	15000	15000	N	N	197.0
282	0.0038	0.105	0.0025	168.5	11.10	1165	9000	N	N	2970	4.95	0.0
303	0.0050	0.061	0.0005	225.5	7.60	856	7500	N	N	1900	5.15	79.5
331	0.0219	0.154	0.0008	206.3	9.43	865	7000	8000	8000	2300	5.20	0.0
359	0.0018	0.149	B	241.5	18.60	985	9000	N	N	3625	5.42	185.9
388	0.0018	0.163	0.0008	240.3	17.70	1018	7000	9100	9100	3300	5.40	163.8
437	0.0033	0.093	0.0033	327.5	14.40	1007	8400	11400	11400	3100	5.39	229.8
458	0.0093	0.258	B	248.3	19.40	1174	9100	10600	10600	3525	5.45	0.0
486	B	0.206	0.0028	262.5	19.10	1209	8000	N	N	3100	5.30	371.3
514	0.0075	0.170	B	260.0	11.45	1132	10000	7900	7900	2940	5.35	438.4
542	0.0030	0.140	N	237.2	13.65	885	8500	6600	6600	3475	5.50	478.8
570	0.0032	0.137	B	197.0	9.12	691	6200	6900	6900	3500	5.65	671.9
598	0.0095	0.082	B	221.5	5.77	615	6500	9200	9200	2500	5.40	327.4
633	0.0020	0.065	B	209.0	4.10	485	4300	4560	4560	2400	5.35	137.4
664	0.0007	0.032	B	207.0	3.42	251	3900	4420	4420	1415	4.60	172.6
689	B	0.032	B	212.5	3.27	493	4300	4150	4150	1300	5.00	141.3
724	0.0002	0.032	B	243.2	1.24	330	4200	4100	4100	2300	5.20	139.6
752	N	N	B	N	N	285	3100	1500	1500	1750	6.30	139.5
780	0.0015	0.027	B	193.8	0.39	477	4000	1400	1400	2550	6.80	119.9
815	0.0230	0.025	N	80.5	0.14	258	3500	240	240	2020	6.62	99.9
843	0.0010	0.045	B	81.0	0.20	276	3400	290	290	2230	7.10	123.8
878	0.0010	0.020	B	80.3	0.65	294	4500	325	325	2600	7.60	106.4
906	0.0010	0.022	B	82.2	B	200	3000	372	372	2560	7.90	436.8
934	0.0010	0.027	B	115.8	0.15	N	2600	408	408	1970	6.20	202.5
969	0.0005	0.015	B	160.0	0.28	555	3300	842	842	2180	6.40	0.0
1053	0.0005	0.030	0.0011	124.7	0.22	205	3900	188	188	1650	6.50	777.8
1150	0.0026	0.004	B	100.3	0.16	N	3000	240	240	2480	6.65	360.7
1235	0.0100	0.025	0.0007	99.5	0.20	243	2000	320	320	N	6.40	980.5
1328	N	N	N	N	N	N	N	N	N	N	N	246.5
1415	N	N	N	N	N	N	N	N	N	N	N	447.1
1510	N	N	N	N	N	N	N	N	N	N	N	297.0

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-8. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS B TREATED GES (13) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0032	0.448	0.0013	255.0	18.50	N	12000	16000	16000	N	N	197.0
282	0.0033	0.050	0.0010	297.3	11.10	1165	9500	N	N	3420	5.10	0.0
303	0.0038	0.083	0.0008	305.0	12.70	1131	9000	N	N	3250	5.35	79.5
331	0.0114	0.141	0.0013	332.5	11.20	1234	7500	10200	10200	3100	5.25	0.0
359	0.0016	0.099	B	350.0	10.90	1072	10000	N	N	3450	5.40	185.9
388	0.0015	0.115	0.0008	290.0	9.05	863	8000	8250	8250	3100	5.35	163.8
437	0.0045	0.013	0.0018	347.5	9.95	720	8000	11400	11400	3525	5.45	229.8
458	B	0.408	0.0008	265.0	8.48	910	8300	7800	7800	2775	5.35	0.0
486	B	0.166	B	297.5	15.30	1111	7500	N	N	2925	5.35	371.3
514	0.0015	0.080	B	327.5	19.35	891	10000	7700	7700	2915	5.20	438.4
542	0.0012	0.050	N	302.5	7.05	731	6700	6200	6200	3150	5.45	478.8
570	B	0.030	B	232.5	5.45	499	4900	5100	5100	2850	5.55	671.9
598	0.0052	0.055	0.0023	248.2	1.55	462	5500	6500	6500	2150	5.50	327.4
633	0.0015	0.030	B	382.5	0.29	428	4000	4740	4740	2250	5.70	137.4
664	0.0002	0.030	0.0013	480.0	B	401	5000	4550	4550	2350	5.80	172.6
689	0.0005	0.047	B	550.0	0.15	472	5700	3100	3100	2600	6.40	141.3
724	B	0.030	B	219.7	B	355	4300	5300	5300	2350	6.30	139.6
752	B	0.030	0.0011	173.0	0.18	330	4000	3200	3200	1950	6.20	139.5
780	0.0012	0.037	B	130.5	B	260	3200	1600	1600	2100	6.60	119.9
815	B	0.022	N	47.0	B	265	3700	180	180	2000	6.80	99.9
843	0.0012	0.027	B	22.1	B	330	3700	258	258	2050	7.40	123.8
878	0.0010	0.015	B	23.6	0.15	278	4000	280	280	2920	7.50	106.4
906	0.0002	0.020	B	23.8	B	315	3800	712	712	2180	7.50	436.8
934	0.0002	0.025	B	52.0	B	270	3600	712	712	2450	6.70	202.5
969	0.0005	0.001	B	55.0	0.07	220	3200	181	181	1830	6.30	0.0
1053	0.0012	0.047	B	88.5	B	220	2500	155	155	1450	6.60	777.8
1150	0.0006	0.003	B	73.8	B	180	3000	190	190	2150	6.25	360.7
1235	0.0060	0.023	B	56.5	B	127	2000	110	110	1100	6.30	980.5
1328	0.0005	0.013	B	61.5	B	N	2000	3600	3600	1600	6.25	246.5
1415	0.0003	0.008	B	49.0	B	63	2000	91	91	1700	6.30	-447.1
1510	0.0017	0.002	B	18.2	B	101	2000	N	N	1600	6.25	297.0

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-9. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS
CONTAINING MSW AND PROCESS A TREATED EPW (14) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	89.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0325	0.328	0.0008	213.0	20.40	1719	9500	N	N	2450	4.90	114.0
331	0.0114	0.291	0.0018	237.5	18.80	1609	9200	12400	12400	3950	5.35	179.0
359	0.0038	0.312	0.0008	229.0	12.70	1519	9500	N	N	4830	5.50	136.3
388	0.0028	0.310	B	218.8	9.78	1279	8500	13200	13200	4100	5.45	123.9
437	0.0105	0.225	0.0025	215.0	7.73	1216	9400	13200	13200	3830	5.50	155.9
458	0.0005	0.195	B	228.5	4.60	1019	10000	10000	10000	3530	5.40	0.0
486	B	0.176	B	226.0	4.85	917	12000	N	N	2600	5.25	158.2
514	0.0017	0.170	B	252.5	10.45	848	9000	9100	9100	2835	5.25	113.6
542	0.0020	0.147	N	270.0	4.25	814	9800	8650	8650	3770	5.55	113.6
570	0.0005	0.142	B	241.7	3.32	692	6400	9550	9550	3500	5.65	126.1
598	0.0027	0.105	B	255.0	3.35	556	7000	7800	7800	2950	5.45	153.7
633	0.0010	0.125	B	272.5	4.75	528	6400	6600	6600	2950	5.45	137.4
664	0.0005	0.050	B	290.0	4.32	546	5800	6980	6980	1850	4.90	155.2
689	0.0012	0.050	B	287.5	4.07	677	6900	7550	7550	2050	5.10	147.1
724	B	0.060	B	300.0	3.40	500	5800	7400	7400	2150	5.10	158.0
752	0.0005	0.055	B	295.0	2.67	540	6600	7200	7200	1700	5.10	108.3
780	0.0015	0.060	0.0006	312.5	2.06	454	4800	7600	7600	950	5.10	110.0
815	B	0.075	N	322.5	1.41	411	6100	7000	7000	818	5.10	104.5
843	0.0015	0.062	B	320.0	1.34	404	7600	5900	5900	252	5.30	110.5
878	0.0017	0.050	B	347.5	2.32	409	7500	6150	6150	4790	5.90	92.7
906	0.0005	0.090	B	407.5	3.55	N	6100	6440	6440	4580	6.00	127.9
934	0.0002	0.087	B	430.0	2.67	350	6600	6880	6880	4470	5.40	115.1
969	0.0012	0.047	B	430.0	1.96	395	7000	6500	6500	1650	5.00	0.0
1053	0.0005	0.062	B	427.5	1.19	347	5400	5050	5050	3300	5.20	361.2
1150	0.0015	0.013	B	472.5	0.73	360	7000	4000	4000	3470	5.20	209.3
1235	0.0153	0.125	B	538.0	0.60	355	6600	5150	5150	2550	5.30	329.7
1328	0.0030	0.033	B	710.0	1.06	N	6200	4150	4150	900	5.15	97.7
1415	0.0018	0.035	B	693.0	0.38	330	6200	4980	4980	850	5.15	292.2
1510	0.0014	0.012	B	182.0	0.66	282	6200	N	N	900	5.15	361.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-10. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED EPW (14) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0060	2.750	0.0018	407.5	25.80	N	13000	15200	15200	N	N	89.0
282	0.0073	0.445	0.0023	322.3	16.60	1737	13000	N	N	3570	5.15	0.0
303	0.0360	0.373	0.0018	367.5	23.80	1627	12000	N	N	4130	5.30	114.0
331	0.0136	0.241	0.0045	282.5	14.40	1839	10000	13600	13600	3900	5.25	179.0
359	0.0103	0.174	0.0098	307.5	14.00	1618	13000	N	N	5330	5.55	136.3
388	0.0015	0.220	0.0010	355.0	10.50	1424	11000	14700	14700	5050	5.50	123.9
437	0.0025	0.213	0.0028	365.0	9.40	1372	10500	14200	14200	4230	5.55	155.9
458	0.0003	0.410	0.0018	340.0	6.63	1263	10500	10000	10000	3900	5.50	0.0
486	B	0.151	0.0005	345.0	7.20	1148	11000	N	N	3400	5.40	158.2
514	0.0010	0.115	0.0015	372.5	6.07	943	11000	7700	7700	3250	5.45	113.6
542	0.0010	0.102	N	410.0	5.40	904	9700	9500	9500	4475	5.65	113.6
570	0.0012	0.070	0.0008	382.5	6.25	896	6500	9500	9500	4000	5.65	126.1
598	0.0017	0.075	0.0013	397.5	6.25	832	9000	13800	13800	4000	5.60	153.7
633	0.0010	0.125	0.0008	392.5	5.45	810	6800	9340	9340	3500	5.35	137.4
664	0.0007	0.142	0.0018	380.0	3.40	704	6600	8500	8500	2350	4.90	155.2
689	B	0.035	B	372.5	2.85	776	8000	8430	8430	2450	5.20	147.1
724	0.0002	0.060	B	397.5	3.20	582	6400	8900	8900	2750	5.00	158.0
752	B	0.057	B	375.0	2.57	482	7800	8000	8000	1900	5.20	108.3
780	0.0007	0.160	0.0009	387.5	2.65	465	4900	7500	7500	1550	5.30	110.0
815	B	0.072	N	377.5	2.87	519	7500	7600	7600	1050	5.20	104.5
843	0.0012	0.127	B	382.5	2.40	543	9000	7300	7300	3080	5.40	110.5
878	0.0035	0.047	B	395.0	1.99	493	9100	7800	7800	5800	5.90	92.7
906	0.0005	0.110	B	425.0	1.81	470	7300	7550	7550	5330	5.90	127.9
934	0.0002	0.080	B	442.5	1.35	420	6800	7200	7200	5170	5.40	115.1
969	0.0007	0.047	B	457.5	2.08	395	7600	6800	6800	1810	5.10	0.0
1053	0.0005	0.065	B	487.5	1.35	417	6200	6050	6050	3750	5.30	361.2
1150	0.0003	0.013	B	495.0	1.23	340	7000	3400	3400	3140	5.15	209.3
1235	0.0025	0.033	B	510.0	0.81	243	5800	3350	3350	2150	5.30	329.7
1328	B	0.040	B	548.0	0.22	N	5400	4530	4530	3650	5.35	97.7
1415	0.0008	0.033	B	733.0	0.50	340	5400	5100	5100	3625	5.25	292.2
1510	0.0003	0.014	B	204.0	0.28	294	5400	N	N	3650	5.35	361.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-11. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (15) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0157	0.338	0.0023	241.3	14.80	N	9000	12000	12000	N	N	234.4
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0023	0.336	0.0010	300.0	21.70	1063	8800	N	N	2950	5.20	92.7
331	0.0219	0.261	0.0015	287.5	19.30	1060	8000	9000	9000	3000	5.55	0.0
359	0.0028	0.279	0.0005	305.0	19.10	978	7000	N	N	3820	5.48	166.9
388	0.0028	0.300	B	310.0	18.30	988	8000	8850	8850	2600	5.13	122.0
437	0.0183	0.303	0.0010	302.5	18.30	946	8100	9200	9200	2560	5.15	152.9
458	0.0008	0.230	B	270.0	12.70	919	8500	7200	7200	2250	5.20	0.0
486	B	0.211	0.0005	255.0	10.70	867	9000	N	N	2150	5.10	135.1
514	0.0012	0.225	B	265.0	5.12	773	9000	7000	7000	2400	5.35	145.7
542	0.0007	0.160	N	282.5	8.95	743	7100	5700	5700	2650	5.40	130.0
570	0.0012	0.152	B	255.0	8.27	656	5500	7200	7200	2615	5.45	127.6
598	0.0017	0.062	B	248.8	6.97	505	5500	8600	8600	1900	5.35	151.4
633	0.0005	0.075	B	249.7	6.60	452	5400	4960	4960	2300	5.25	95.0
664	0.0007	0.135	0.0005	282.5	7.42	537	4700	5720	5720	1375	4.60	132.1
689	B	0.035	B	262.5	4.77	394	3800	4400	4400	1050	5.10	129.3
724	B	0.075	B	292.5	7.72	470	4600	6700	6700	1650	4.90	120.6
752	0.0005	0.085	B	295.0	7.00	555	5300	6500	6500	1450	5.10	105.9
780	0.0005	0.060	B	297.5	4.87	396	3700	N	N	900	5.20	124.9
815	B	0.060	N	282.5	4.02	386	5200	4900	4900	633	5.15	51.9
843	0.0015	0.065	B	282.5	4.07	407	5700	4400	4400	1750	5.70	123.8
878	0.0027	0.047	B	310.0	2.85	283	7800	4400	4400	4470	5.80	99.2
906	0.0007	0.062	B	327.5	2.65	260	3800	4150	4150	2610	6.20	103.0
934	B	0.040	B	317.5	2.33	265	4000	4090	4090	2610	5.50	100.3
969	0.0012	0.042	B	300.0	2.01	208	3800	3270	3270	8000	5.30	155.9
1053	0.0007	0.070	B	327.5	3.80	84	4400	4100	4100	2250	5.30	303.1
1150	0.0009	0.014	B	455.0	1.46	400	6000	3400	3400	2970	5.25	252.4
1235	0.0100	0.043	B	493.0	3.55	370	5600	4100	4100	2200	5.30	225.5
1328	0.0010	0.030	B	585.0	2.75	N	5200	3840	3840	3880	5.35	224.9
1415	0.0065	0.038	B	713.0	3.48	490	5200	6430	6430	3850	5.35	357.1
1510	0.0006	0.002	B	310.0	1.55	426	5200	N	N	3800	5.35	275.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-12. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS
CONTAINING MUNICIPAL SOLID WASTE ONLY (15) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0185	0.361	0.0055	287.5	11.80	N	5000	13500	13500	N	N	234.4
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0030	0.121	0.0050	390.0	19.00	1307	9800	N	N	3500	5.30	92.7
331	0.0161	0.236	0.0038	447.5	17.50	1322	8000	11000	11000	3300	5.20	0.0
359	0.0023	0.237	0.0020	437.5	18.40	1065	8900	N	N	3450	5.29	166.9
388	0.0040	0.203	0.0008	385.0	16.60	929	8500	9000	9000	2950	5.13	122.0
437	0.0050	0.213	0.0038	387.5	16.90	876	7100	8600	8600	2585	5.19	152.9
458	0.0028	0.165	0.0015	365.0	12.30	890	7500	7500	7500	2675	5.20	0.0
486	B	0.144	B	360.0	12.90	901	8000	N	N	1950	5.00	135.1
514	0.0030	0.135	0.0005	370.0	10.17	800	8500	8200	8200	2739	5.25	145.7
542	0.0010	0.122	N	360.0	9.20	782	8200	8850	8850	3050	5.35	130.0
570	B	0.070	B	322.5	8.77	716	5600	7200	7200	3035	5.40	127.6
598	0.0030	0.062	0.0005	320.0	8.32	689	6500	10700	10700	2650	5.45	151.4
633	0.0015	0.060	B	330.0	7.90	630	6100	4110	4110	2550	5.40	95.0
664	0.0007	0.142	0.0053	337.5	8.02	567	5200	6780	6780	1330	4.80	132.1
689	B	0.067	B	292.5	7.10	647	5400	6450	6450	1800	5.00	129.3
724	B	0.060	B	295.0	5.92	679	6300	8200	8200	2050	4.90	120.6
752	0.0005	0.085	B	295.0	8.00	632	5400	7100	7100	1550	5.20	105.9
780	B	0.052	B	267.5	6.75	482	5200	N	N	1150	5.20	124.9
815	B	0.035	N	302.5	5.70	565	6200	6400	6400	797	5.10	51.9
843	0.0007	0.070	B	302.5	5.50	280	7300	5900	5900	2230	5.40	123.8
878	0.0015	0.060	B	255.0	4.50	551	4900	7350	7350	2760	6.00	99.2
906	0.0007	0.067	B	196.0	4.45	520	6400	6560	6560	3940	6.00	103.0
934	0.0007	0.047	B	249.3	4.38	473	6000	6380	6380	3890	5.40	100.3
969	0.0012	0.045	B	272.5	4.27	467	6500	6000	6000	1700	5.10	155.9
1053	0.0007	0.047	B	151.3	8.75	496	5600	5550	5550	5200	5.30	303.1
1150	B	0.012	B	402.5	2.92	330	5000	3100	3100	2640	5.20	252.4
1235	0.0048	0.028	B	840.0	0.39	380	7000	4200	4200	3650	5.50	225.5
1328	0.0150	0.030	B	808.0	0.55	N	6000	4210	4210	1650	5.85	224.9
1415	0.0035	0.023	B	1470.0	0.27	490	6000	5790	5790	1700	5.90	357.1
1510	0.0027	0.009	B	388.0	0.06	360	6000	N	N	1650	5.85	275.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-13. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (16) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	156.1
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0280	0.138	0.0030	402.5	10.60	1442	6000	N	N	N	4.35	81.7
331	0.0079	0.154	0.0020	229.3	6.75	1245	6700	9600	9600	1750	5.05	0.0
359	0.0021	0.167	0.0020	320.0	9.38	1231	7500	N	N	3210	5.35	153.3
388	0.0040	0.192	0.0008	287.5	7.38	1225	9000	10100	10100	3100	5.36	127.3
437	0.0004	0.188	0.0025	290.0	7.83	1077	7100	9800	9800	2985	5.40	147.2
458	0.0008	0.178	B	257.5	7.43	1138	8000	8200	8200	2750	5.40	0.0
486	B	0.088	0.0005	362.5	6.80	1168	8300	N	N	2725	5.25	127.9
514	0.0005	0.207	0.0010	405.0	6.77	1003	9800	8200	8200	2800	5.20	176.4
542	B	0.182	N	425.0	6.02	1078	9300	9900	9900	3710	5.50	72.2
570	0.0080	0.132	0.0008	472.5	5.95	1022	6500	9750	9750	3750	5.55	117.0
598	N	N	N	N	N	978	7500	9600	9600	2925	5.45	138.6
633	0.0015	0.202	N	660.0	8.52	1135	8500	N	N	4650	5.70	173.0
664	0.0005	0.377	0.0013	710.0	6.65	1056	7800	10700	10700	3240	5.10	119.6
689	N	N	B	N	N	645	N	9480	9480	2000	5.50	115.3
724	B	0.300	B	630.0	6.22	1095	8400	10300	10300	2450	5.30	119.9
752	N	N	B	N	N	971	8000	11000	11000	2650	5.50	119.6
780	B	0.332	B	587.5	5.30	1036	3300	10250	10250	337	5.70	117.3
815	N	N	N	N	N	N	N	N	N	N	N	106.0
843	N	N	B	N	N	N	N	N	N	N	N	109.8
878	N	N	B	N	N	N	N	N	N	N	N	118.1
906	N	N	B	N	N	N	N	N	N	N	N	84.8
934	N	N	B	N	N	N	N	N	N	N	N	77.2
969	N	N	B	N	N	N	N	N	N	N	N	96.5
1053	N	N	B	N	N	N	N	N	N	N	N	447.8
1150	N	N	B	N	N	N	N	N	N	N	N	251.0
1235	N	N	N	N	N	N	N	N	N	N	N	214.6
1328	N	N	N	N	N	N	N	N	N	N	N	248.4
1415	N	N	N	N	N	N	N	N	N	N	N	356.9
1510	N	N	N	N	N	N	N	N	N	N	N	330.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-14. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MUNICIPAL SOLID WASTE ONLY (16) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0105	0.306	0.0113	292.5	19.10	N	13000	24000	24000	N	N	156.1
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	B	0.121	0.0005	193.0	9.65	1461	10000	N	N	3700	5.40	81.7
331	0.0061	0.334	0.0025	292.5	10.30	1365	9400	12400	12400	2900	5.30	0.0
359	0.0038	0.155	0.0028	255.0	6.60	1491	11000	N	N	3190	5.30	153.3
388	0.0073	0.127	0.0010	280.0	6.35	1446	8500	11000	11000	2450	5.10	127.3
437	0.0053	0.080	0.0023	305.0	5.18	1243	7900	11000	11000	3150	5.31	147.2
458	0.0003	0.080	0.0015	407.5	4.85	1199	8500	8700	8700	2650	5.30	0.0
486	B	0.058	B	395.0	3.95	1087	11000	N	N	2550	5.40	127.9
514	0.0007	0.070	0.0005	480.0	3.77	942	10000	8400	8400	3025	5.40	176.4
542	0.0007	0.040	N	600.0	2.55	915	8500	6900	6900	3515	5.65	72.2
570	0.0235	0.017	0.0013	735.0	2.16	777	6400	7400	7400	3650	5.70	117.0
598	0.0012	0.050	0.0018	692.5	2.52	819	7500	7500	7500	3440	5.85	138.6
633	0.0010	0.040	0.0005	840.0	2.57	755	7200	4010	4010	3500	5.95	173.0
664	B	0.167	0.0005	675.0	2.85	785	5800	7820	7820	2110	5.30	119.6
689	B	0.067	N	612.5	2.34	745	6600	6700	6700	2250	5.50	115.3
724	B	0.057	B	620.0	2.36	635	5900	7600	7600	2050	6.90	119.9
752	0.0007	0.387	B	560.0	5.05	610	6100	6200	6200	2150	5.70	119.6
780	B	0.045	B	655.0	1.86	566	5600	5400	5400	247	6.00	117.3
815	B	0.027	N	832.5	1.08	504	6900	2700	2700	232	5.65	106.0
843	0.0007	0.062	B	797.5	1.08	530	7400	5000	5000	2950	5.80	109.8
878	0.0002	0.065	B	580.0	1.22	535	6700	5550	5550	4310	5.30	118.1
906	0.0012	0.100	B	755.0	1.10	500	6400	5090	5090	4470	6.70	84.8
934	0.0007	0.042	B	710.0	1.16	483	5200	5850	5850	3570	6.10	77.2
969	0.0017	0.130	B	612.5	1.73	620	7200	6800	6800	2500	5.70	96.5
1053	B	0.050	B	617.5	1.57	506	5600	4600	4600	2550	5.60	447.8
1150	0.0004	0.005	B	392.5	1.34	350	6000	4200	4200	4040	5.65	251.0
1235	0.0013	0.043	B	400.0	1.17	350	6400	3700	3700	2700	7.00	214.6
1328	0.0023	0.035	B	565.0	1.09	440	4900	4425	4425	3050	5.60	248.4
1415	0.0045	0.048	B	540.0	2.26	470	4900	4975	4975	3025	5.60	356.9
1510	0.0004	0.006	B	181.0	1.13	624	4900	N	N	3050	5.60	330.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-15. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED CPB (17) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0167	0.083	B	176.3	23.30	N	15000	13000	13000	N	N	189.0
282	0.0048	0.088	0.0028	207.3	40.00	5616	16500	N	N	4530	5.00	0.0
303	0.0010	0.063	B	241.8	26.50	5243	14000	N	N	2550	5.35	85.9
331	0.0114	0.101	0.0015	221.3	23.50	5536	12500	8300	8300	2880	5.50	0.0
359	0.0043	0.099	B	267.5	31.50	5434	15500	N	N	3950	5.45	132.9
388	0.0003	0.250	0.0008	220.0	20.30	5540	14500	9900	9900	3430	5.45	156.6
437	0.0043	0.260	0.0010	212.5	17.60	5789	12100	10600	10600	3210	5.40	173.7
458	0.0023	0.200	B	267.5	17.70	5580	10000	8550	8550	3050	5.40	0.0
486	B	0.174	B	255.0	17.60	5579	11000	N	N	2450	5.20	135.5
514	0.0007	0.135	0.0005	332.5	17.65	4652	17100	9400	9400	3165	5.35	107.1
542	0.0005	0.125	N	380.0	16.10	4913	15400	9600	9600	3800	5.55	119.7
570	0.0030	0.127	0.0008	380.0	17.32	4765	10500	8300	8300	3850	5.55	114.7
598	0.0012	0.055	0.0010	420.0	17.15	4819	12600	8150	8150	3385	5.55	142.7
633	0.0105	0.125	B	412.5	16.80	N	12000	7900	7900	3925	5.55	154.4
664	0.0002	0.077	0.0005	372.5	15.42	4187	10000	7480	7480	2050	4.80	32.9
689	B	0.097	B	340.0	16.90	5350	15000	7500	7500	1200	4.80	161.2
724	B	0.090	B	242.5	11.10	5240	15100	7100	7100	1400	4.90	100.6
752	0.0015	0.177	B	225.2	11.52	5080	15000	7400	7400	1250	5.20	61.3
780	B	0.072	B	275.0	12.90	4428	13500	6500	6500	1100	4.95	122.6
815	0.0005	0.052	N	262.5	14.27	4441	13000	5500	5500	121	4.91	117.0
843	0.0010	0.077	B	260.0	13.42	4344	14000	5500	5500	2500	5.50	94.6
878	0.0005	0.105	B	355.0	12.30	3110	14000	6350	6350	4730	5.10	102.2
906	0.0005	0.102	B	312.5	13.17	4050	13000	5400	5400	3980	5.80	100.3
934	0.0002	0.050	B	372.5	14.70	4645	13000	7280	7280	4580	5.60	99.2
969	0.0020	0.050	B	367.5	13.27	4515	15000	6950	6950	1810	5.30	0.0
1053	0.0010	0.162	B	325.0	13.85	4690	14400	4600	4600	2450	5.20	404.2
1150	0.0010	0.067	B	315.0	17.25	3000	19000	6600	6600	6190	5.60	235.0
1235	0.0020	0.130	B	395.0	11.00	761	19000	5300	5300	3250	5.40	334.6
1328	0.0080	0.040	B	405.0	16.00	N	19000	5810	5810	3050	5.45	143.5
1415	0.0173	0.165	B	430.0	6.35	2100	18000	7300	7300	3050	5.50	168.8
1510	0.0011	0.005	B	218.0	1.01	1760	19000	N	N	3050	5.45	419.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-16. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED CPB (17) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0127	0.273	0.0023	330.0	10.00	N	19000	18000	18000	N	N	189.0
282	0.0118	0.055	0.0035	144.5	7.85	5665	17500	N	N	3380	5.10	0.0
303	0.0108	0.058	0.0010	197.8	10.80	5633	16500	N	N	3080	5.36	85.9
331	0.0094	0.056	0.0020	195.8	8.80	6048	15000	7100	7100	2900	5.40	0.0
359	0.0088	0.087	0.0013	252.5	19.80	5571	16200	N	N	3150	5.33	132.9
388	0.0025	0.080	0.0013	370.0	20.50	5577	15000	10200	10200	3820	5.50	156.6
437	0.0033	0.140	0.0288	407.5	18.00	5046	12000	13200	13200	4070	5.58	173.7
458	B	0.113	0.0028	407.5	13.70	5494	11500	7700	7700	3480	5.40	0.0
486	B	0.076	0.0008	375.0	9.18	5561	9500	N	N	2750	5.35	135.5
514	0.0007	0.060	0.0013	462.5	11.10	4973	17000	7000	7000	4110	5.85	107.1
542	0.0007	0.050	N	540.0	10.10	5045	15600	7500	7500	3650	5.65	119.7
570	0.0012	0.020	0.0018	525.0	12.35	4883	11000	6400	6400	3650	5.60	114.7
598	0.0015	0.065	0.0025	437.5	11.47	5022	12900	6300	6300	3375	5.65	142.7
633	0.0010	0.050	0.0005	397.5	9.62	N	11500	7080	7080	3025	5.60	154.4
664	0.0002	0.042	0.0018	482.5	13.90	4269	10800	6820	6820	2100	5.00	32.9
689	B	0.070	B	360.0	10.57	6180	17000	6600	6600	1450	5.00	161.2
724	B	0.135	B	402.5	13.00	4600	14000	8300	8300	1750	4.90	100.6
752	0.0112	0.145	0.0070	470.0	12.37	4350	14000	8200	8200	1950	5.30	61.3
780	B	0.052	B	352.5	11.02	4594	15000	5800	5800	1250	4.90	122.6
815	0.0002	0.045	N	330.0	9.57	4408	13000	6000	6000	175	5.15	117.0
843	0.0005	0.070	B	377.5	11.50	4983	16000	5900	5900	2150	5.70	94.6
878	0.0002	0.070	B	312.5	8.30	3450	15000	5850	5850	4200	4.80	102.2
906	0.0015	0.117	B	377.5	11.35	4050	13000	5350	5350	4470	6.00	100.3
934	B	0.040	B	422.5	14.77	4330	13000	N	N	4310	5.60	99.2
969	0.0007	0.055	B	350.0	11.72	4890	15000	5850	5850	1700	4.90	0.0
1053	0.0015	0.092	B	402.5	18.25	5310	13000	4900	4900	2300	5.30	404.2
1150	0.0002	0.006	B	380.0	1.36	1150	17000	5600	5600	5690	5.60	235.0
1235	0.0015	0.048	B	388.0	6.08	938	17000	3700	3700	1650	5.40	334.6
1328	B	0.150	B	413.0	B	N	17000	4120	4120	2950	5.45	143.5
1415	0.0048	0.133	B	515.0	0.34	1580	17000	5350	5350	2950	5.45	168.8
1510	0.0016	0.005	B	133.0	0.24	1770	17000	N	N	2450	5.45	419.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-17. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED GES (18) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0052	0.423	0.0013	332.5	42.00	N	12000	18500	18500	N	N	83.0
282	0.0025	0.278	0.0008	327.3	29.50	1848	13000	N	N	5237	5.20	0.0
303	B	0.288	B	360.0	29.00	1749	12000	N	N	5050	5.50	166.2
331	0.0071	0.259	0.0018	367.5	26.50	1677	9000	7300	7300	4100	5.40	0.0
359	0.0108	0.269	B	300.0	19.60	1464	13500	N	N	4880	5.50	128.3
388	0.0225	0.252	B	295.0	17.30	1482	12000	11200	11200	4460	5.48	179.7
437	0.0033	0.233	0.0045	285.0	14.20	1236	8000	13000	13000	4210	5.49	453.4
458	0.0008	0.190	B	267.0	12.20	999	8000	8160	8160	3700	5.40	0.0
486	B	0.148	B	270.0	11.20	942	6500	N	N	3350	5.35	203.7
514	0.0010	0.082	B	272.5	11.70	854	10000	8400	8400	2275	5.65	194.2
542	0.0017	0.485	N	275.0	7.42	811	8200	6250	6250	3685	5.50	282.0
570	0.0020	0.145	0.0008	239.2	6.32	639	5000	3900	3900	3500	5.50	208.2
598	0.0005	0.100	B	243.5	7.10	571	6000	4400	4400	2825	5.45	212.4
633	0.0010	0.060	B	235.0	6.80	480	5200	6170	6170	3650	5.60	201.7
664	0.0005	0.080	0.0008	238.2	6.25	360	4900	5450	5450	1800	4.90	152.4
689	B	0.060	B	248.5	6.10	460	5800	6000	6000	1300	4.90	149.1
724	B	0.042	B	272.5	5.52	259	4400	6500	6500	9000	4.80	186.9
752	0.0032	0.130	B	265.0	3.82	258	4100	3300	3300	900	5.00	101.1
780	B	0.052	B	290.0	4.32	378	4500	5800	5800	550	4.65	132.8
815	0.0007	0.040	N	307.5	6.20	502	4600	4700	4700	85	4.80	123.4
843	0.0007	0.070	B	330.0	6.70	222	5000	5150	5150	1650	5.00	129.8
878	0.0050	0.105	B	325.0	6.63	225	6000	5450	5450	3560	4.30	113.9
906	0.0007	0.107	B	367.5	6.17	180	4200	4920	4920	3250	5.80	244.9
934	0.0005	0.042	B	355.0	4.07	200	4200	5620	5620	3250	5.00	234.7
969	0.0015	0.037	B	330.0	6.63	330	4400	5220	5220	1010	4.80	0.0
1053	0.0010	0.225	B	330.0	5.42	238	4200	3450	3450	1500	5.10	396.6
1150	0.0003	0.013	B	357.0	4.37	470	4500	4100	4100	3050	5.25	306.0
1235	0.0018	0.010	B	465.0	7.05	542	3800	3700	3700	1850	4.80	440.2
1328	0.0028	0.033	B	575.0	7.65	137	3600	3650	3650	1250	5.05	211.4
1415	0.0088	0.013	B	420.0	7.50	105	3600	3550	3550	1250	5.05	231.7
1510	0.0008	0.004	0.0013	B	B	142	3600	N	N	1250	5.05	392.6

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-18. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND PROCESS A TREATED GES (18) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0290	0.531	0.0020	275.0	10.20	N	11000	15000	15000	N	N	83.0
282	0.0165	0.250	0.0035	522.3	10.60	1943	13000	N	N	5481	5.30	0.0
303	0.0088	0.251	0.0015	552.5	11.10	1908	13200	N	N	4950	5.50	166.2
331	0.0079	0.111	0.0013	550.0	10.40	1832	9000	11000	11000	4250	5.40	0.0
359	0.0063	0.229	0.0015	492.5	9.43	1819	14500	N	N	5430	5.55	128.3
388	0.0200	0.145	B	467.5	8.18	1502	13500	12000	12000	4930	5.52	179.7
437	0.0025	0.133	0.0028	367.5	5.65	1232	9000	12700	12700	4195	5.58	453.4
458	0.0015	0.160	B	295.0	3.60	869	9300	7950	7950	3400	5.50	0.0
486	B	0.136	B	300.0	4.08	872	9000	N	N	2900	5.40	203.7
514	0.0027	0.085	0.0005	310.0	4.90	772	9300	8200	8200	4050	5.65	194.2
542	0.0015	0.192	N	325.0	5.60	739	8300	5600	5600	3730	5.60	282.0
570	0.0010	0.040	0.0010	275.0	5.77	559	6000	6500	6500	3325	5.50	208.2
598	0.0025	0.075	0.0008	250.0	3.72	446	5200	6400	6400	2500	5.45	212.4
633	0.0020	0.070	B	238.8	3.52	360	5000	5620	5620	2725	5.45	201.7
664	0.0007	0.055	0.0010	255.0	3.30	337	4300	5600	5600	1750	4.90	152.4
689	B	0.045	B	262.5	4.87	327	6300	5720	5720	1750	5.10	149.1
724	B	0.060	B	307.5	2.60	298	4500	6600	6600	9000	4.80	186.9
752	0.0007	0.150	B	277.5	0.79	298	5000	5200	5200	850	5.10	101.1
780	0.0012	0.047	B	317.5	6.20	291	4200	5800	5800	1350	4.70	132.8
815	B	0.042	N	297.5	3.50	272	5000	5300	5300	1160	4.90	123.4
843	0.0015	0.070	B	300.0	4.42	268	5800	5300	5300	2020	5.20	129.8
878	0.0002	0.060	B	357.5	4.38	307	5400	5950	5950	3990	4.30	113.9
906	0.0012	0.105	B	347.5	3.45	260	4500	5260	5260	3620	5.80	244.9
934	0.0002	0.047	B	467.5	3.82	200	4100	6060	6060	3350	5.20	234.7
969	0.0010	0.035	B	357.5	3.40	205	4600	2710	2710	1060	4.80	0.0
1053	0.0005	0.415	B	320.0	1.72	208	3500	3550	3550	1400	5.10	396.6
1150	0.0003	0.011	B	360.0	2.60	150	4100	3900	3900	3380	5.25	306.0
1235	0.0018	0.053	B	385.0	2.58	152	4200	3500	3500	1650	5.00	440.2
1328	0.0008	0.033	B	558.0	4.50	192	3800	3870	3870	1500	5.00	211.4
1415	0.0118	0.020	B	478.0	3.28	160	3800	3350	3350	1500	5.20	231.7
1510	0.0005	0.005	0.0016	168.0	1.17	122	3800	N	N	1500	5.00	392.6

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-19. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED EPW (19) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	153.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.0120	0.343	0.0008	185.0	14.60	1213	7000	N	N	1100	4.80	114.3
331	0.0156	0.341	0.0020	195.5	3.48	1000	9000	8200	8200	3450	5.30	0.0
359	0.0083	0.314	B	198.5	7.33	1267	7500	N	N	4430	5.50	201.7
388	0.0038	0.335	B	262.5	12.80	1480	11000	12600	12600	4980	5.45	134.5
437	0.0050	0.255	0.0038	315.0	7.85	1117	8200	11200	11200	5000	5.50	158.2
458	0.0040	0.243	B	325.0	6.70	1115	7500	9000	9000	4375	5.50	0.0
486	N	N	B	N	N	N	N	N	N	N	N	127.2
514	0.0090	0.377	B	420.0	0.84	734	11300	8000	8000	4750	6.00	115.5
542	0.0047	0.410	N	365.0	0.39	756	8700	5850	5850	5175	6.20	106.8
570	0.0900	0.660	0.0005	515.0	B	538	6500	4400	4400	4925	6.45	118.5
598	0.0055	0.545	B	460.0	0.06	561	6300	4300	4300	4450	6.70	111.7
633	0.0025	0.430	B	365.0	B	728	6700	5620	5620	3875	6.45	135.9
664	0.0012	0.313	0.0008	360.0	B	548	6700	5520	5520	3650	5.60	137.8
689	B	0.375	B	347.5	B	405	9000	5460	5460	3900	6.20	127.1
724	B	0.225	B	427.5	6.52	615	7100	6400	6400	2450	5.50	87.1
752	B	0.292	B	432.5	B	672	7800	7000	7000	2600	5.60	109.4
780	0.0180	0.242	B	442.5	0.18	648	6600	5800	5800	2600	5.90	110.9
815	B	0.147	N	58.8	0.14	499	5900	1000	1000	3300	6.81	92.7
843	0.0037	0.137	B	17.5	0.13	513	6600	414	414	3560	7.00	99.2
878	0.0032	0.127	B	50.3	0.62	556	6400	510	510	3560	6.70	107.1
906	0.0037	0.115	B	20.3	0.15	535	6000	468	468	4470	6.90	51.5
934	0.0032	0.085	B	16.3	B	470	5400	1240	1240	3780	6.90	61.7
969	0.0035	0.070	B	19.9	0.14	535	5800	375	375	3990	7.00	0.0
1053	0.0010	0.077	0.0002	21.6	B	452	5400	262	262	3350	6.90	320.6
1150	0.0250	0.006	B	41.2	0.41	370.	6200	950	950	5850	7.30	280.4
1235	0.0028	0.050	B	19.5	0.25	390	6000	330	330	3400	7.40	348.2
1328	0.0080	0.063	B	6.9	B	390	4100	168	168	3250	7.05	287.1
1415	0.0048	0.040	B	6.4	B	280	3900	140	140	3200	7.00	283.1
1510	0.0022	0.045	B	2.4	0.05	335	4100	N	N	3250	7.05	348.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-20. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED EPW (19) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0112	0.188	0.0013	330.0	1.32	N	10000	10500	10500	N	N	153.0
282	0.0030	0.125	0.0015	322.3	1.06	1445	12600	N	N	4711	5.35	0.0
303	B	0.093	0.0008	342.5	1.35	1070	10000	N	N	4175	5.65	114.3
331	0.0081	0.241	B	372.5	2.08	1122	8000	7600	7600	3925	5.50	0.0
359	0.0011	0.124	B	385.0	1.27	1100	10000	N	N	4600	5.70	201.7
388	0.0015	0.170	0.0013	352.5	3.10	920	13000	8500	8500	4530	5.50	134.5
437	B	0.128	0.0010	662.5	0.16	1010	8000	10900	10900	5125	5.70	158.2
458	0.0005	0.155	B	612.5	B	1014	8000	7350	7350	4675	5.70	0.0
486	B	0.114	B	572.5	B	862	7200	N	N	3875	5.60	127.2
514	0.0007	0.030	B	575.0	B	808	10000	8800	8800	5850	6.05	115.5
542	B	0.317	N	705.0	B	814	4500	4700	4700	5960	6.05	106.8
570	0.0025	0.020	B	642.5	B	716	7400	7450	7450	5540	6.05	118.5
598	B	0.065	B	665.0	0.04	750	7000	7400	7400	4550	6.25	111.7
633	0.0010	0.065	B	722.5	B	522	7500	7620	7620	6500	6.30	135.9
664	0.0002	0.025	0.0010	680.0	B	740	7000	6680	6680	4175	5.80	137.8
689	B	0.175	B	590.0	B	653	9500	6920	6920	5000	6.10	127.1
724	B	0.045	B	600.0	B	729	7600	8400	8400	3200	5.70	87.1
752	B	0.180	B	682.5	B	756	8800	7800	7800	3300	5.80	109.4
780	B	0.130	B	700.0	B	756	7200	6500	6500	2500	5.60	110.9
815	B	0.047	N	592.5	B	704	9000	6800	6800	3480	6.00	92.7
843	0.0005	0.155	B	715.0	B	870	11000	7750	7750	4680	5.80	99.2
878	0.0032	0.127	B	415.0	B	771	9000	6630	6630	6440	6.70	107.1
906	0.0072	0.107	B	146.5	B	845	8100	2140	2140	5590	6.90	51.5
934	0.0025	0.072	B	22.3	0.17	836	6400	1760	1760	4630	7.50	61.7
969	0.0250	0.065	0.0003	29.3	0.18	735	7400	715	715	4520	7.10	0.0
1053	0.0002	0.130	B	33.8	B	586	5400	360	360	3300	6.90	320.6
1150	0.0135	0.026	B	11.5	B	450	6500	350	350	6680	7.30	280.4
1235	0.0020	0.050	B	4.5	0.14	355	4500	270	270	3150	7.00	348.2
1328	0.0175	0.028	B	30.3	B	302	3900	118	118	2850	7.10	287.1
1415	0.0040	0.033	0.0013	35.5	B	360	3800	138	138	2950	7.15	283.1
1510	0.0006	0.010	B	1.2	B	304	3900	N	N	2850	7.10	348.8

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-21. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED CPB (20) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.3722	0.366	0.0030	125.3	36.80	N	39000	12000	12000	N	N	155.0
282	0.3975	0.410	0.0030	146.5	42.00	47642	50000	N	N	2395	4.60	0.0
303	0.2800	0.378	0.0038	143.5	42.30	56330	46000	N	N	2000	5.10	63.2
331	0.2921	0.271	0.0039	135.0	40.30	59794	40000	9300	9300	2450	5.10	0.0
359	0.4023	0.274	0.1353	142.0	41.50	60029	46500	N	N	3100	5.20	250.2
388	0.5425	0.310	0.0450	119.0	32.30	59561	40000	11200	11200	3030	5.29	150.5
437	0.3200	0.435	0.0125	125.0	33.50	53833	47000	13000	13000	2975	5.15	145.3
458	0.0640	0.085	0.0790	85.3	13.60	47384	63000	10000	10000	3650	5.35	127.3
486	0.0423	0.236	0.0520	85.8	10.10	45726	60000	N	N	3125	5.60	99.6
514	0.0172	0.167	B	92.7	2.80	41944	50000	N	N	N	5.95	108.6
542	N	N	N	N	N	N	N	N	N	N	N	101.8
570	N	N	N	N	N	N	N	N	N	N	N	114.3
598	N	N	N	N	N	N	N	N	N	N	N	121.1
633	0.0005	0.160	0.0008	16.7	0.19	31499	22500	6300	6300	4950	5.70	135.5
664	0.0110	0.057	0.0033	8.9	0.20	15730	30000	7000	7000	4825	5.60	124.8
689	B	0.142	0.0010	5.2	B	8820	34000	6450	6450	5000	6.20	139.6
724	0.0005	0.075	B	1.8	B	60000	30000	7700	7700	1400	5.60	124.2
752	B	0.220	0.0030	9.6	B	13250	25000	7200	7200	4900	6.20	97.3
780	B	0.172	0.0006	52.7	B	10210	30000	N	N	8200	5.90	137.7
815	0.0022	0.060	N	208.5	0.14	7839	24000	5500	5500	7920	6.35	90.1
843	0.0007	0.045	0.0010	200.7	0.14	10600	26000	5900	5900	6230	6.90	82.1
878	0.0012	0.037	0.0014	190.0	0.22	6296	23000	4100	4100	6390	6.80	102.6
906	0.0007	0.035	0.0021	58.2	0.16	14600	20500	2610	2610	7300	6.90	59.8
934	0.0015	0.025	0.0024	33.3	B	6540	17000	2700	2700	6120	7.60	93.5
969	0.0015	0.032	0.0010	15.2	0.16	6450	19000	7200	7200	5910	7.20	0.0
1053	0.0015	0.032	B	17.6	B	6948	15200	425	425	4900	7.20	313.8
1150	0.0040	0.019	0.0020	22.5	0.16	830	16000	425	425	8000	7.50	205.9
1235	0.0063	0.020	0.0022	13.5	B	127	14800	360	360	4450	7.00	304.2
1328	0.0020	0.028	0.0023	18.6	B	0	8700	281	281	2100	7.05	217.0
1415	0.0073	0.025	0.0015	13.3	B	95	8700	253	253	2000	7.05	206.7
1510	0.0004	0.007	B	5.0	B	112	8700	N	N	2100	7.05	300.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-22. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED CPB (20) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.4522	0.108	0.0053	10.6	21.60	N	52000	9500	9500	N	N	155.0
282	0.3875	0.265	0.0045	13.4	34.50	75399	60000	N	N	1486	4.60	0.0
303	0.3725	0.263	0.0023	14.8	34.30	76802	65000	N	N	1100	4.75	63.2
331	0.6071	0.326	0.0038	31.0	32.30	73727	60000	7900	7900	800	4.70	0.0
359	0.4900	0.327	0.0058	33.8	32.50	70600	67500	N	N	1680	5.00	250.2
388	0.3900	0.335	0.0208	59.0	33.80	57971	58500	11400	11400	2430	5.15	150.5
437	0.4200	0.320	0.0075	55.0	27.80	52232	41000	13000	13000	2425	5.10	145.3
458	0.0773	0.065	0.0030	63.8	21.10	51392	57000	10500	10500	4100	5.25	127.3
486	0.0105	0.191	0.0110	87.5	11.00	40453	63000	N	N	2950	5.20	99.6
514	0.0042	0.065	0.0048	110.7	6.75	38280	60000	11100	11100	4725	5.70	108.6
542	0.0017	0.177	N	219.5	2.05	36726	28600	7100	7100	6210	5.80	101.8
570	0.0050	0.130	0.0033	226.0	0.61	32177	24000	10000	10000	5960	5.75	114.3
598	B	0.027	0.0030	267.5	0.19	29034	26900	11000	11000	5650	6.05	121.1
633	0.0235	0.055	0.0035	290.0	B	N	35000	9380	9380	5200	5.95	135.5
664	0.0350	0.047	0.0015	345.0	B	22778	35000	8720	8720	5350	5.60	124.8
689	B	0.147	B	282.5	B	14330	40000	8250	8250	3500	5.90	139.6
724	0.0010	0.057	B	4.1	B	48500	35000	8300	8300	3650	5.70	124.2
752	B	0.200	B	4.4	B	17750	27000	8000	8000	4800	6.00	97.3
780	0.0032	0.142	N	27.5	B	10210	27000	N	N	8000	6.00	137.7
815	0.0027	0.037	N	57.7	B	8738	28000	2700	2700	5490	6.40	90.1
843	0.0007	0.022	B	20.4	B	9421	29000	3200	3200	6280	7.00	82.1
878	0.0017	0.025	B	20.9	B	6558	27000	2200	2200	5690	7.00	102.6
906	0.0010	0.017	B	3.1	B	N	22000	1250	1250	7080	7.00	59.8
934	0.0002	0.017	0.0010	9.5	B	8935	18000	1450	1450	6440	7.80	93.5
969	0.0010	0.020	0.0005	4.4	B	4465	20000	440	440	5960	7.50	0.0
1053	0.0022	0.017	0.0010	6.0	B	5956	15000	280	280	4050	7.30	313.8
1150	0.0031	0.002	0.0012	10.0	0.14	N	18000	870	870	6770	7.65	205.9
1235	0.0020	0.010	0.0029	10.0	0.01	76	14500	330	330	3750	7.40	304.2
1328	0.0015	0.025	0.0043	11.7	0.18	88	9000	343	343	2350	7.10	217.0
1415	0.0063	0.010	0.0009	5.7	B	105	9200	185	185	2350	8.00	206.7
1510	0.0005	0.004	0.0014	2.4	0.12	112	9000	N	N	2350	7.00	300.9

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-23. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED GES (21) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	137.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	0.2875	0.338	0.0035	146.5	0.43	1208	8000	N	N	3350	5.30	35.6
331	0.0134	0.159	0.0013	337.5	1.17	1545	9000	10700	10700	3350	5.20	0.7
359	0.0015	0.257	B	337.5	1.04	1425	8000	N	N	3850	5.20	166.6
388	0.0015	0.253	B	355.0	0.59	1340	9000	9600	9600	3950	5.35	122.7
437	0.0028	0.150	N	210.0	0.41	1126	1800	6600	6600	3470	6.10	139.7
458	0.0015	0.133	B	46.8	0.24	1113	8300	930	930	7050	7.15	110.2
486	B	0.028	B	29.8	0.13	1123	8500	N	N	4525	6.95	44.3
514	0.0030	0.027	B	30.7	0.24	1210	10000	800	800	4725	7.35	70.8
542	0.0012	0.217	N	68.0	0.26	547	10500	5500	5500	N	7.35	243.4
570	0.0022	0.017	B	66.3	0.13	843	5500	500	500	3650	7.05	148.4
598	B	0.045	0.0378	76.5	0.16	858	6400	550	550	3300	7.05	149.5
633	0.0015	0.010	B	63.2	B	780	6000	372	372	3300	7.00	74.9
664	0.0077	0.017	B	62.0	B	615	4500	425	425	3150	6.40	82.1
689	0.0015	0.020	B	81.5	B	1982	9000	935	935	3650	6.70	96.1
724	0.0020	0.017	B	65.5	B	692	4700	400	400	1900	6.30	131.3
752	0.0022	0.017	0.0013	55.2	B	480	4700	520	520	2500	6.50	138.9
780	0.0010	0.015	N	55.5	B	485	4000	N	N	2500	6.60	205.5
815	B	0.022	N	41.3	B	499	4600	260	260	2710	6.72	101.1
843	0.0020	0.020	B	43.2	0.13	399	5600	238	238	2710	7.10	374.0
878	0.0020	0.015	B	36.3	B	435	6400	190	190	6070	6.20	151.4
906	0.0007	0.015	B	35.0	B	425	4600	205	205	2930	6.60	182.4
934	0.0005	0.015	B	42.5	B	438	4400	803	803	2770	6.80	205.1
969	0.0005	0.012	B	40.5	B	467	4800	145	145	2820	6.80	0.0
1053	0.0002	0.012	0.0010	40.7	B	387	4300	175	175	2550	6.80	492.8
1150	0.0003	0.001	B	31.0	B	330	N	485	485	4790	7.15	241.8
1235	0.0018	0.028	B	23.4	B	335	4500	105	105	2800	7.00	379.7
1328	0.0008	0.108	B	22.8	B	346	4000	118	118	3350	7.15	267.5
1415	N	N	B	N	N	240	4000	82	82	3350	7.20	188.9
1510	0.0004	B	B	10.3	0.06	218	4200	N	N	3350	7.00	273.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-24. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW AND UNTREATED GES (21) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0060	0.721	0.0013	247.5	0.67	N	10000	11000	11000	N	N	137.0
282	0.0005	0.170	B	269.8	0.25	1255	10000	N	N	4277	5.30	0.0
303	B	0.143	0.0005	370.0	0.91	958	10000	N	N	4525	5.50	35.6
331	0.0131	0.151	0.0008	405.0	0.52	2059	9000	10100	10100	3650	5.30	0.7
359	0.0010	0.167	B	415.0	0.36	1407	11000	N	N	4450	5.45	166.6
388	0.0010	0.160	B	540.0	0.13	1331	13000	10000	10000	4500	5.49	122.7
437	0.0015	0.123	N	715.0	0.11	1303	7800	11200	11200	3610	5.40	139.7
458	0.0003	0.058	B	527.5	B	1231	5700	6750	6750	4850	5.25	110.2
486	B	0.016	B	215.5	B	1142	8300	N	N	3575	6.60	44.3
514	0.0015	0.015	B	62.7	B	982	7100	500	500	5925	7.40	70.8
542	0.0010	0.152	N	52.7	B	811	7600	4800	4800	3525	6.95	243.4
570	0.0025	B	B	56.3	B	743	5000	250	250	3650	7.05	148.4
598	B	0.017	B	60.2	B	875	6400	300	300	1500	6.90	149.5
633	0.0010	0.025	B	46.5	B	N	5500	322	322	3450	6.95	74.9
664	0.0060	0.007	N	49.5	B	737	4700	283	283	2675	6.50	82.1
689	B	0.015	B	62.2	B	646	5600	305	305	3050	6.80	96.1
724	0.0010	0.010	B	41.0	B	510	4800	400	400	2950	6.40	131.3
752	B	0.012	0.0073	41.5	B	660	4400	510	510	2500	6.60	138.9
780	N	N	N	N	N	605	3700	N	N	2400	6.60	205.5
815	B	0.017	N	29.0	B	509	4900	300	300	N	6.58	101.1
843	0.0007	0.012	B	25.0	B	483	5100	238	238	2500	7.00	374.0
878	0.0007	0.007	B	24.9	B	412	4700	155	155	3240	6.40	151.4
906	0.0007	0.012	B	27.2	B	415	4100	180	180	2560	6.50	182.4
934	0.0005	0.007	B	36.0	B	420	4200	777	777	2770	6.90	205.1
969	0.0125	0.010	B	33.3	B	467	4500	181	181	2660	6.70	0.0
1053	0.0005	0.020	B	27.5	B	422	4500	130	130	2400	6.80	492.8
1150	0.0003	B	B	22.1	B	280	4400	435	435	N	7.15	241.8
1235	0.0060	0.033	B	17.5	B	294	4100	135	135	2350	7.00	379.7
1328	0.0013	0.020	B	21.8	B	434	4200	103	103	2250	7.00	267.5
1415	0.0108	0.005	B	24.9	B	250	4200	100	100	2150	7.15	188.9
1510	0.0004	B	0.0006	5.6	B	228	4200	N	N	2250	7.00	273.1

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-25. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (22) FOR ABOVE-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	N	N	B	N	N	N	N	N	N	N	N	76.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	N	N	B	N	N	N	N	N	N	N	N	38.2
331	N	N	B	N	N	N	N	N	N	N	N	0.0
359	N	N	B	N	N	N	N	N	N	N	N	54.5
388	N	N	B	N	N	N	N	N	N	N	N	39.5
437	N	N	B	N	N	N	N	N	N	N	N	49.2
458	N	N	B	N	N	N	N	N	N	N	N	0.0
486	N	N	B	N	N	N	N	N	N	N	N	36.7
514	N	N	B	N	N	375	5500	N	N	1985	5.65	35.2
542	N	N	B	N	N	N	N	N	N	N	N	34.6
570	N	N	B	N	N	N	N	N	N	N	N	31.4
598	N	N	B	N	N	N	N	N	N	N	N	33.3
633	N	N	B	N	N	N	N	N	N	N	N	39.0
664	N	N	B	N	N	N	N	N	N	N	N	31.8
689	N	N	B	N	N	N	N	N	N	N	N	34.5
724	N	N	B	N	N	N	N	N	N	N	N	63.2
752	N	N	B	N	N	N	N	N	N	N	N	19.7
780	N	N	B	N	N	N	N	N	N	N	N	21.2
815	N	N	B	N	N	N	N	N	N	N	N	24.2
843	N	N	B	N	N	N	N	N	N	N	N	27.6
878	N	N	B	N	N	N	N	N	N	N	N	31.0
906	N	N	B	N	N	N	N	N	N	N	N	28.4
934	N	N	B	N	N	N	N	N	N	N	N	29.5
969	N	N	B	N	N	N	N	N	N	N	N	33.7
1053	N	N	B	N	N	N	N	N	N	N	N	132.5
1150	N	N	B	260.0	2.55	N	N	N	N	N	N	65.1
1235	N	N	N	N	N	N	N	N	N	N	N	59.4
1328	N	N	N	N	N	N	N	N	N	N	N	38.5
1415	N	N	N	N	N	N	N	N	N	N	N	96.9
1510	N	N	N	N	N	N	N	N	N	N	N	67.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)

TABLE D-26. LEVELS OF PARAMETERS TAKEN QUARTERLY FROM TEST CELLS CONTAINING MSW ONLY (SMALL SIZE) (22) FOR BELOW-SOIL LEACHATE SAMPLES

DAYS	CADMIUM	CHROMIUM	MERCURY	IRON	ZINC	CHLORIDE	COND	TOC	TVA	ALKA	PH	VOLUME
247	0.0072	0.141	0.0068	915.0	5.60	N	9500	11000	11000	N	N	76.0
282	N	N	B	N	N	N	N	N	N	N	N	0.0
303	B	0.048	0.0008	755.0	6.28	960	8700	N	N	3800	5.65	38.2
331	0.0051	0.066	0.0018	520.0	7.45	857	7100	9300	9300	2950	5.45	0.0
359	0.0005	0.087	B	387.5	7.23	815	8500	N	N	3220	5.50	54.5
388	0.0010	0.050	0.0004	322.5	4.83	651	8000	7800	7800	2680	5.43	39.5
437	0.0028	0.053	N	295.0	5.78	510	5900	6800	6800	2280	5.42	49.2
458	0.0010	0.060	0.0005	255.0	4.90	436	8500	5900	5900	2450	5.20	0.0
486	B	0.059	0.0008	252.5	4.78	360	8500	N	N	1400	5.20	36.7
514	0.0012	0.047	B	236.5	4.75	301	5000	4350	4350	1870	5.35	35.2
542	0.0007	0.022	N	232.2	4.05	260	4800	3200	3200	1790	5.45	34.6
570	0.0002	0.010	B	214.5	3.80	201	3200	3500	3500	1700	5.45	31.4
598	0.0005	0.015	0.0002	217.2	3.87	178	3500	4500	4500	1500	5.50	33.3
633	B	0.030	0.0005	218.0	3.37	148	3500	3250	3250	1550	5.35	39.0
664	0.0087	0.020	0.0008	230.5	2.95	127	2800	3000	3000	795	4.90	31.8
689	B	0.025	B	244.0	2.92	117	3100	2900	2900	800	5.20	34.5
724	0.0015	0.017	B	250.0	2.47	90	2500	3600	3600	150	4.90	63.2
752	B	0.030	B	228.0	2.20	80	2700	2700	2700	600	5.10	19.7
780	B	0.022	B	262.5	2.06	78	2500	N	N	600	5.20	21.2
815	B	0.040	N	228.2	1.76	80	2600	1400	1400	337	5.10	24.2
843	0.0012	0.040	B	240.0	1.97	153	2800	2100	2100	950	5.50	27.6
878	0.0010	0.032	B	246.9	2.24	260	2900	2280	2280	1860	5.70	31.0
906	0.0017	0.057	B	285.0	2.47	60	2800	2300	2300	1700	5.90	28.4
934	0.0005	0.035	B	287.5	2.72	50	2400	2900	2900	1810	5.00	29.5
969	0.0007	0.025	B	307.5	2.56	47	2900	2560	2560	852	4.90	33.7
1053	0.0002	0.037	B	297.5	3.02	32	2300	2400	2400	1400	5.30	132.5
1150	0.0009	0.009	B	N	N	78	3000	1600	1600	1570	5.00	65.1
1235	0.0053	0.025	B	423.0	2.46	86	2400	2115	2115	1050	5.00	59.4
1328	B	0.023	B	423.0	4.08	N	2100	1920	1920	1050	5.25	38.5
1415	0.0088	0.010	B	458.0	4.43	79	2200	2000	2000	1050	5.25	96.9
1510	0.0006	0.037	B	156.0	1.77	127	2100	N	N	1050	5.25	67.7

NOTE: ALL VALUES IN MG/L EXCEPT PH (STANDARD UNITS) AND VOLUME (L)